【Provisional】

New Robot Strategy

Japan's Robot Strategy

- Vision, Strategy, Action Plan -

The Headquarters for Japan's Economic Revitalization

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Part I General Statement

Chapter 1 Prologue

Section 1 Current situation surrounding "Japan as a robotics superpower"

Subsection 1 Japan as a robotics superpower

Robots have become rapidly common in Japan since the 1980's primarily in the manufacturing sector. In particular, the automobile, electric and electronic industries showed a significant growth against the backdrop of greater labor productivity in line with the full-fledged employment of robots as the major destination for supply of robots. It goes without saying that these industries have played an active role for Japan to usher in an era of *Japan as No. 1* driven indeed by the utilization of robots.

In addition, robots have always been in the spotlight in Japan for diverse potentials and there have been noteworthy innovative achievements such as pet-like robots aiming to provide comfort and surprise to human or world-leading research and development on human-shaped robots and study of service robots.

Japan's excellence in the field of robotics has particularly been notable in the area of industrial robots which have been employed ahead of others. Japan has maintained its global position as the world's number one supplier of industrial robots in value, and also tops in the number of units in operation till present. As of 2012, Japan earned the shipment value of about JPY340 billion which accounts for approximately 50% of the global share as well as the number of units in operation (based on stocks) of roughly 300,000 units which accounts for 23% of the global share. In addition, 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.

As evidenced above, Japan continues to maintain its status as "Robotics Superpower " till present built on its world-renowned strengths in diverse areas of robot production, utilization, supply of key parts, research and development.

Subsection 2 Japan as an advanced country of challenging issues

Japan has been faced with the issues of declining birth rate and ageing society which are progressing at an unparalleled speed worldwide and thus Japan has become one of the first among other nations to encounter such challenges as a decline in the number of working-age population, shortage in labor and higher social security costs as a result of the issues above.

Indeed the number of senior citizens aged 65 and above hit the record-high level of over 31.9 million as at 1 October 2013 and their percentage against the total population (population aging rate) also marked a record 25.1%.

The number of working-age population is also on the decline and currently dips below the level of 80 million to 79.01 million. Social security costs hit a record JPY108.5568 trillion in the fiscal year 2012 amid such environment, accounting for 30% against the national income.

In addition, there are myriad issues that require immediate systematic actions from the entire society for protection of our lives including enhanced disaster preparedness and upgrading of aged social capitals to cope with heavy rain disasters occurring more often than ever in recent years.

For industries, there is no doubt about declining global competitiveness in the manufacturing sector for instance and amount of value-added production has been shrinking to the point where nearly JPY20 trillion has been lost at least in the past 20 years. There is tendency that some sectors count on overseas production for lower operation costs. However from a viewpoint of maintaining and fortifying global competitiveness of the Japanese economy towards the future, enhancing domestic geographical advantage is a challenge that is as crucial as keeping pace with the expansion of overseas market.

To meet these challenges, advancing reform of the socioeconomic system is of course indispensable, and further initiatives must also be taken by gathering all knowledge and expertise available including utilization of new technical innovation.

Subsection 3 Catch-up of other countries by the robot as a key to growth

Robots are back in the limelight once again in recent years as the key to growth across the world including both developed countries like Europe and America as well as emerging economies represented by China.

The US government released the “National Robotics Initiative” in 2011 providing tens of millions of dollars every year to support fundamental research on robots mainly in the fields of Artificial Intelligence (AI) and recognition (voice, image etc).

In addition, Google, a major IT enterprise originating from US, drew global attention last December when it bought over seven venture companies one after another (worth USD60 million) to obtain promising robot technologies possessed by these companies. Among the seven acquired companies is one of the top players in DARPA Robotics Challenge held by the Defense Advanced Research Projects Agency (DARPA) of the United States Department of Defense since 2012.

In Europe, the “EU SPARC Project” was launched in 2014 as a research and innovation project in the field of robotics through collaboration between the European Commission and around 180 private companies and research bodies in order to go ahead with the development of practical robots for use in the manufacturing, agricultural, health and hygiene, transportation, civil social security and household sectors. As part of the overall initiatives there is a project worth EUR2.8 billion in total through investments of approximately EUR700 million from the European Commission and EUR2.1 billion from private companies and research bodies.

Key highlight of these movements in Europe is the transformation of society where physical objects are interconnected through network which is called Internet of Things (IoT[1]) has become more realistic in line with the rapid progress of digitalization as well as advancement of network and cloud technologies. Countries in Europe and America are seemingly aiming to win the lead in utilization of new robots by cashing in on these changes. On the other hand, China has been aggressively employing state-of-the-art industrial robots as part of the countermeasures against rising labor costs, or efforts to secure higher quality. The Chinese government advocates the "Development Plan for Intelligent Manufacturing Equipment Industry" (智能製造装置産業発展計画) (2012)" aiming to hit a domestic sales target for industrial robots of 3 trillion yuan by 2020 which is ten times as much as the current level. As evidence of the trend, robots have been embraced rapidly in China and the annual number of robot units (flow) employed in 2005 of 4,000 has soared to 37,000 in 2013, beating Japan and pushing China to the top of the world.

Section 2 Drastic transformation of robots and Japan's future

Subsection 1 Drastic transformation of robots

Amid such environment, robots have started to make drastic transformation themselves along with technology innovation and changes in business models.

The very first change is that robots are shifting themselves from those doing simple routine tasks to "autonomous" ones equipped with self-learning abilities and action initiatives. There is much expectation for further enrichment of robot capacities in line with a great leap in the advancement of AI technology (image, voice recognition, machine learning) including utilization of deep learning in addition to the progress of separate technologies such as sensor technology and higher performance of software and information processing capacity, which altogether will enable a more skilled processing.

The second highlight is that robots grow from the conventional ones that are put under unilateral data control to new ones acting as a source of added value such as new service by means of piling up and making use of various data on their own, triggering a trend of "robot transformation into an information terminal device" replacing such existing devices as personal computers and mobile phones. These robots may possibly be embraced across the corners of our daily lives and for instance, robots are expected to advance into the area of

[1] A situation where several physical objects are equipped with sensor and connected to the Internet

routine communication tools and contribute to provide life support such as assistance in household choirs as well as safety and comfort.

The last point is a trend where robots become interconnected for mutual cooperation as a “networked” tool beyond the scope of individual tasks as a single robot, through which robots will function not only as a single robot but also as a part of various systems and their importance has been growing more than ever with the arrival of IoT society.

Subsection 2　Encroaching crisis on Japan as a great country of robotics

As robots transform themselves to “autonomous” “information terminal device” and “networked” ones, they are used mainly in the field of automated production process in Japan aimed at stable production and energy saving and thus the mainstream of Japan remains that robots are utilized with tailored specs for individual usage only in specific areas of the manufacturing sector such as the automobile, electric and electronic industries equipped with excellent mass production technology.

On the contrary, public-private initiatives have been gaining momentum in the manufacturing sector of America and Europe on top of initiatives taken at the individual corporate level for the establishment of new business model such as the case of Google as aforesaid. For instance, the Industrial Internet Consortium[2] was set up in US and Germany is aggressively pushing forward the Industry 4.0[3] Strategy aiming at development of new production process and optimization of supply chain on the whole. To capitalize on these trends, establishing the global standards and modules in the eyes of mutual alliance is the key to success and much focus has been gathered on how to win a status as a new platform for exchange of a wide range of information.

Should Japan lag behind such trend in terms of ideas about robot development or perspectives of business models, Japan will be isolated from the rest of the world in the field of robotics as well and be eyed as Galapagos which will draw more concerns over the situation in Japan where craftsmanship enjoys a victory but business suffers a defeat. To ride these global tides, it is imperative to recruit human resources equipped with knowledge in the fields of system establishment, launch and programming including areas given high added value in the course of robot employment even at present like designing production

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2　A consortium of over 60 companies headed by GE and including Cisco, IBM and Intel, deliberating on sharing of the best practice and matters requiring standardization with respect to a system utilizing data collected from industrial equipment loaded with measurement device and analyzed for the purpose of maintenance, servicing or design and development.

3　Part of the strategic measures mapped out by the German government in November 2011 under the “High-Tech Strategy 2020 Action Plan”, based on which 57 key German companies formed a council including BMW and Siemens aiming at overall optimization of development, manufacturing and logistics processes.

process and teaching, or software knowledge involving utilization of digital data and development of AI which will grow more important than ever in future. However, there is not enough opportunity to nurture and utilize such human resources in these fields in Japan. As evidence of the trend, it has become a growing trend in recent years for precious bright students to find jobs overseas on their own, posing an immense challenge in both terms of human resource nurturing and utilization.

The same applies to the field of system integrator ("SIer[4]") as the key to systematic utilization of robots which is only employed in projects catering to specific major companies in the automobile, electric and electronic industries at present. Immediate measures must be taken to supplement the shortage in quality and quantity of SIer in order to cover an extensive range of new fields other than the automobile industry such as manufacturing and service sectors as well as major small-to-medium companies.

Subsection 3 Formation of future Japan built on new robots

A major innovation in robotics including robot technology and robot utilization system will, once achieved, could serve as an extremely effective tool in the easement of social challenges faced with Japan in the eyes of global robotics trend and current situation surrounding Japan.

Furthermore, such new innovation in robotics can be accelerated by setting and striving to reach a specific and integrated goal. Therefore, Japan has a huge potential of honing itself to become global hub of robot innovation by capitalizing on its status as a leading nation of challenges, and as a result, Japan will be able to spread across the world its future-oriented system utilizing robots.

In particular, huge amount of data collected through practical and specific utilization of robots will serve all the more as a driving force for the advancement of robots (data-driven innovation[5]) in IoT era where digital data and virtual network play an active role. Therefore, the entire Japan can be positioned as the center for world-leading innovation and demonstration site for utilization of the world's state-of-the-art robot technology (robot demonstration) through relentless efforts in the formation of a society where robots are put to maximum use by myriad sophisticated users in both business (B to B) and consumer (B to C) markets.

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4 System Integrator

5 "DATA-driven Innovation for Growth and Well-being"(December 2014 by OECD)

Section 3 Goal of robot revolution

Subsection 1 Transformation of robots in Japan

Robot revolution refers to:

1) turning what used not to be positioned as robot in conventional manners into robots through the advancement of sensor and AI technologies (eg. automobile, household appliance, mobile phone or housing will be considered a type of robots.);

2) utilizing robots in the actual site of manufacturing as well as various scenes of daily life which will lead to;

3) forming a society where new added value, convenience and wealth are created through the reinforcement of global competitiveness in the field of manufacturing and service as well as settlement of social issues.

To make this robot renovation come true, Japan's robots must be changed.

First of all, "easy to use" platform must be available to achieve universal user friendliness as well as equipping robots with flexibility to cater to various needs across fields. So far, robots have primarily been embraced by major companies in the automobile, electric and electronic industries upon tailoring for a merger into large-sized key production lines. Future robots in demand will be the ones catering to the needs of greater manufacturing fields including the major three "supplies" industries (food supplies, cosmetic supplies and medical and pharmaceutical supplies), service industry where scope of tasks ranges widely with different requirements as well as small and medium-sized companies relying mainly on human workforce. Having this in mind, robots catering to the needs of small and medium-sized companies must be designed not to be large for specific tasks like welding or coating but be smaller and capable of performing multi-purpose tasks while ensuring cost-effectiveness in the actual operation.

Similar efforts must be taken in the fields where robots have already been well utilized in operation. It is imperative to set high goals apart from the scope of conventional technology and seek methods in order to develop a robot which is readily available for frequent changes in manufacturing process adaptable to high-mix low-volume production or to establish a method of designing reasonable production system by use of the robots with aforesaid flexibility.

In addition, structural transformation must take place on the side of robot suppliers, SIer and users to gain higher added value than ever for enhanced application of these robots based on the resourceful perspectives of capitalizing on technology development to reinforce individual competitive edge as well as benefits of standardization as a common asset of all the parties involved while identifying source of competitiveness of each party built on unique creativity and recognizing common cost structure.

In the course of transformation into "flexible robots with universal user-friendliness" as illustrated above, it is also important to make module-driven robots to become the mainstream robot model under a common platform catering to diverse needs through different module combinations.

The initiatives above must be followed by the next step of advancing the module-driven robots to IT-integrated ones to meet the demand for creation and utilization of robots equipped with such functionality as "autonomous", "data-terminal" and "network" acting as the global trend leader. Through such initiatives, robots will continue to serve as a source for new added value in the fields of manufacturing and service in order to keep pace with blooming data-driven innovation and extensive rivalry in data acquisition and utilization while performing the function of delivering a wide range of information and contents to people acting as a key device for major innovation in the areas of entertainment or daily interaction.

Moreover, robot concepts must be stretched as well for the maximization of a trend of new innovation and potential for development through flexible approach to robot concepts. In contrast to the conventional viewpoints of reckoning robots as a machine equipped with three systematic elements of sensor, intelligence/control and actuator[6], there is an emerging fresh structure built on the advancement of digitalizatioin, enrichment in cloud computing and other network foundations and progress of AI where robots can be driven by independent intelligence/control based on AI enabling access to various people and objects in real world without the help of specific actuation system[7]. Further advancement of IoT

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6 Definition of industrial robots set out by JIS

7 For instance, a system of developing and offering sensor and intelligence/control systems alone is sufficient for robots to function such as loading drive application on smart phone OS (iOS or Android) for smart phones to function as remote controller device.

and standardization of data-driven devices such as actuators will make it feasible for intelligence/control system alone to offer a range of robot functions in various scenes of society. The conventional definition of robots may no longer be conclusive in the advent of the new phase in robotics as illustrated above where only the machinery equipped with the three systematic elements constitute robots[8]. We must keep broad perspectives of robots for the future in mapping out a shape of next-generation robots.

In addition to above, a society and structure must undergo a transformation to take full advantage of robots. Despite rapid advancement of robots, some point out that there is a huge limit in what robots can do as compared to what human can do to recognize and cope with diverse situations and therefore we should not expect a dramatic leap in robotics in mid-term. Having said that, it is crucial to meet the requirements for a society where human and robots can coexist and cooperate on a daily basis for the maximization of robot capacities. Such kind of society can be called “robot barrier-free society” which should realized.

Once a “robot barrier-free society” comes true, there will be routine collaboration between robots and human of all ages from children to seniors. Robots will help release human from cumbersome tasks and enrich interaction for a higher quality of life than ever. In addition, taking full advantage of robots for greater safety, comfort and attractiveness of a community will contribute to the formation of a highly attentive and convenient community that human alone may not come by. In particular, routine operation of robots in the actual scenes of medicine and nursing care in the ever-progressing aging society with declining birth rate will enable provision of advanced medical care that used to be impossible or quality nursing service with lesser burden which will bring about a deeper appreciation for robots by each individual. Tactful employment of robots in various scenes of society will lead to a formation of various new industries (maintenance, contents, entertainment, insurance etc) one after another in collaboration with robots.

[8] The statements do not deny that robots create new value by having near-human appearance or response

Subsection 2　Three pillars of robot revolution

Japan’s strategy will be summarized into the following three pillars for the achievement of robot revolution envisaged above.

1) Global base for robot innovation – Drastic reinforcement of robot creativity

In order for Japan to emerge as a hub for successive creation of revolutionary robots through drastic reinforcement, it is proposed that Japan set up a structure triggering innovation through promotion of public-private partnership, creation of more occasions for matching of users and manufacturers, as well as pressing ahead with normalization and standardization under the perspectives of human resource development, next-generation technology development and global expansion.

2) World’s leading society maximizing robot capacity – showcasing (realization of daily life with robots)

In order for Japan to create and make full use of robots truly useful in the wide fields of manufacturing undertaken not only by large but also major small and medium-sized companies, service, nursing and medical care, infrastructure and disaster preparedness, construction and agriculture, is necessary that Japan press ahead with strategic development and employment of robots while improving environmental readiness as a prerequisite to utilize robots.

3) World’s leading strategy for a new robot era

In a data-driven society where digital data is put to a sophisticated use under IoT, every object is connected through network and generates big data daily. Furthermore, the data itself serves as a source for added value. Japan should map out a strategy based on perspectives of a new robot era in the advent of such society.

To make such society come true, initiatives must be taken to set up rules to promote business built on autonomous data accumulation and utilization through interconnection among robots as well as to win the global standards. In pursuit of above, it is imperative to ensure security and safety rules as well as their standardization for maximum stretching of potentials derived from the new robot era.

It is also necessary that Japan press ahead with a robot project worth JPY 100 billion through solicitation of private investments in robot development by making full use of multiple pump-priming policies ensuring systematic and environmental readiness through regulatory reform by the government.

In the course of these initiatives, Japan should advocate the viewpoint that robots do not function as a simple human replacement but must be utilized as an effective tool of “supplement to human and partner to help human move up to a more value-added phase”.

Chapter 2 Measures for realization of robot revolution

Section 1 Robot creativity – Thorough reinforcement of robots in Japan

The first measures to achieve robot revolution are "thorough reinforcement of robot creativity".

Subsection 1 Building infrastructure for innovation

Concerted efforts must be taken first and utmost to realize innovation of creating robots one after another which will lead to social reform by means of building system and infrastructure for Japan to emerge as the world's top robot innovation hub.

As specific measures towards the achievement of robot revolution, a wide range of stakeholders must clarify each of their assignments as well as sharing the progress with other parties. As part of such initiatives, "Robot Revolution Initiative" will be set up as a core collaboration channel to press ahead with material progress. The Robot Revolution Initiative will undertake such tasks as 1) promotion of public-private collaboration and matching between users and manufacturers as well as collection and dissemination of relevant information, 2) planning and drafting of international joint research projects in view of global developments such as joint development of robots for disaster preparedness by Japan and the US, 3) strategic drafting and utilization of global standards, proposal on regulatory reform and setting up rules on data security, and 4) sharing and popularization of the best practice.

In addition, infrastructure must be established for demonstration experiments (robot demonstrative experiments) to examine the way of utilizing a wide range of new robots as a key drive for robot revolution and a frontier-runner. A field for demonstrative experiments will be provided equipped with sufficient space for robot demonstrative experiments as well as freedom from conventional institutions capitalizing on special zone system. Furthermore, a system will be established which will continue to act as a innovation hub towards the future where domestic and foreign challengers undertaking robot revolution will get together and precise response will be ready to meet several requirements for various demonstrative experiments that may lead to exploration of potential needs.

In pressing ahead with the initiatives above, a close liaison will be maintained with the Council for Science, Technology and Innovation in charge of overall coordination and establishment of comprehensive strategy on science, technology and innovation.

Subsection 2 Human resource development

Initiatives must be taken to nurture key human resources for the achievement of robot revolution such as SIer for assembly of robot system, or IT specialists to operate core software in the robot system.

First, some measures should be introduced to increase occasions for building robot spending systems headed by SIer on the actual scenes for nurturing SIer through OJT. In addition, skilled personnel will be utilized having expertise and knowhow on design and formation of robot-led production line so far in order to enhance the base for core personnel exerting Japan's potential to the maximum.

Furthermore, positive consideration should be given from a medium to long-term perspective on measures to nurture specialists for creation and employment of robots through such initiatives as support for human resource development such as SIer taking full advantage of public vocational training for employed workers, certification and qualification systems , education and development of relevant resources at research institutes and universities, and support for personnel challenging new development or start of business.

To nurture specialists, sufficient care must be given to ensure information security.

In addition, measures should be discussed for people to deepen literacy for robots which is imperative for collaboration and coexistence with them such as wide dissemination of knowledge on robots as part of primary and secondary educations or making full use of social educational facilities such as science museum for people to get familiarized with robots and their effective usage on a daily basis while understanding operation structure of robots.

Subsection 3 Preparing for the next generation

(1) Development and promotion of next-generation technology

In order for Japan to remain the state-of-the-art mainstream technology towards the future in the fast-changing robot and AI fields, research and development of the next-generation technology for robot and AI is imperative. In doing so, research and development will be focused on the core technology (AI, sensing and recognition, mechanism and actuation, control etc) as brain, eyes and fingers of the robots valued in a data-driven society while incorporating innovation in extensive fields beyond the frame of conventional wisdom (energy source, material, communication, security, big data, human interface etc). In addition, developed technology will be put to a practical use immediately.

Refreshing operability and usability of robots is as important as enhancing robot functions through development and practical operation of these technologies. For instance, advancement in the field of voice recognition technology is expected to help develop a robot with greater operability and usability through human instinct.

In technology development, research and development of several element technologies will be carried out at the same time while encouraging open innovation through inter-technology collaboration and information sharing by hosting such occasions as workshop or award competition (challenge program).

(2) Normalization and standardization in view of global development

To be prepared for upcoming global development of robots created in Japan, it is important to set global standards and specifications in advance and go ahead with practical operation in line with such standards and specifications.

In the course of above, under the technological trend that highly integrated and collaborated robot systems are becoming key factor, intensive efforts must be made for normalization and standardization of individual device, software including middleware (robot OS etc), interface for building networked robot systems, communication protocol for device interoperability as well as functionality appraisal for robot system consisted of these devices and software.

Furthermore, discussions must be held swiftly for normalization and standardization of surrounding technologies such as palette in logistics and building designing in maintenance in order to advance the employment of robots.

In promoting these standardization initiatives, public and private sectors will collaborate in discussion of specific measures and dissemination of information to global society through active engagement with the Robot Revolution Initiative for the establishment of infrastructure on which robot-related business in Japan can get competitiveness in global market.

Section 2 Utilization and popularization of robots – “Daily life with robots” across Japan

The second measures for the realization of robot revolution are the “utilization and popularization of robots” aimed at maximum use of robots to settle various imminent challenges while emerging as the state-of-the-art robot innovation hub at the same time.

Subsection 1 Utilization in various fields based on goals by the sector

(1) Fundamental viewpoints on the utilization of robots

Extensive employment of robots in labor-intensive and low-productivity areas of each field or areas of monotonous repetitive works and heavy labor will be encouraged to help make up for a shortage of workforce as well as taking full advantage of human resources in areas of high added value.

In addition, scope of robot utilization will be enlarged by encompassing the entire operational process as a whole including not only a single phase of robot employment but also other processes before and after the employment of robots.

For instance, a foundation will be established to undertake formation, distribution, processing and utilization of data on work flow and work environment as an effective tool for smooth transition from human work to robot work. By taking these measures in a way to suit the reality of each field, the entire system will be optimized for maximum utilization of robot functions in various fields.

Through such initiatives, we aim to drastically improve productivity and go ahead with realization and popularization of a ground-breaking process such as 24-hour automated operation which will lead to a greater added value and drastic reinforcement of productivity in Japan on the whole.

(2) Stipulation and implementation of KPI by sector

We will set up a strategic goal as KPI to be achieved by 2020 as well as an action plan for the fulfillment of goal in each field of manufacturing, service, nursing and medical care, infrastructure and disaster preparedness, construction and agriculture base on which we will take necessary actions.

We will consistently press ahead with the entire process from robot development for market entry to employment on the actual scene through proactive engagement by every stakeholder including robot users, manufacturers, universities and administrative bodies for the achievement of goal by 2020.

(3) Various fields where further utilization of robots is expected

There are several fields with high potential for robot utilization in addition to the above fields advocating KPI by sector such as the entertainment field where robot is not a human replacement but creates new values on its own, or the space field where robots perform tasks under extreme conditions where human being is unable to adapt, and there is much expectation for future development of these fields in a form of ripple effect on other fields encouraging greater application of robot technology and outcome of technology development.

In conclusion, we will continue to monitor the development of relevant technology and market trend in these potential fields while carrying on discussions to promote utilization and popularization of robots in more fields by stipulation of KPI and action plans like these fields described above.

Subsection 2 Cross-sectional initiatives to support flexible utilization of robots

(1) Promotion of robot employment centered by system integrator

It is imperative to strengthen functions of system integration which pick up various needs from users, gather manufacturers, match users and manufacturers and establish a robot system for robots to be utilized in various fields.

In addition, for SIer to establish a business model as an independent service operator of above functions as well as strengthening business foundation, a technology infrastructure must be set up enabling simplified system integration and flexibility to satisfy diverse needs. Enlarged application of module-driven robots (hardware/software) is a key to tackling these challenges. Expansion of business while curbing integration costs will be feasible through development and supply of modules by various companies based on widely-accepted standards to meet various purposes through their combination by SIer.

(2) Greater entry by various operators

For robots to be put to a daily use across Japan, not only existing robot manufacturers but also small and medium companies, venture capitals and IT enterprises are expected to enter the robot market. For instance, there may emerge companies which used to be a robot user but were motivated to enter and show their strength in new projects to create and utilize robots in the field of robot maintenance, management and improvement. To enable such scenario, the Robot Revolution Initiative will go ahead with information sharing and infrastructure building.

(3) Reform of regulations and institutions for utilization of robots

To promote and enlarge utilization of robots in real society, a well-balanced reform of regulations and institutions must be carried out from a viewpoint of both deregulation and establishment of rules.

In particular, among many institutions not based on the scenario of robot utilization, reform is necessary to encourage advanced utilization of robots. Measures will be taken to establish new rules for collaboration of human and robots based on thorough understanding of reality about robots and collaboration with the Regulatory Reform Council while abolishing unnecessary regulations at the same time.

Section 3　Development and progress of robot revolution on global perspectives – Toward new advanced IT society

The third measures for the achievement of robot revolution are to create a platform for innovation led by robots in a new advanced IT society while aiming at leading the world's robot revolution.

Subsection 1　Winning strategy in a data-driven society

(1) Intensifying competitions surrounding object data in real society

In line with the progress of IoT generating a wide range of data and transforming added value obtained from resourceful utilization of data and socioeconomic aspects, a data-driven society seems coming.

Competitions are growing more intense at present over acquisition and utilization of data as a source for value in a data-driven society. Similar competitions have taken place on the Internet over the online data loaded by people along with the growth of the Internet, and they have entered a new phase of competitions to obtain immense data collected via the sensor employed in various activities of real society in recent years.

So far, major Internet business companies have seized the global platforms in the field of search engine and social networking service to collect every sort of information available on the Internet. In addition, they continue to extend their own platform by providing services with higher added value capitalizing on the collected data and thus winning advantageous positions in global data competitions.

In ever-intensifying data competitions in real life in future, there will be another competition for establishment of a platform to obtain data collected from sensors tagged to various activities in real life. In such case, robots will form the core in a data collection platform in future due to their huge potential for utilization across fields in society and act as a key device for winning the data collection competition in a data-driven society. In the back of the major Internet business companies' minds is such intention that drive them to aggressively merge robot companies.

Transforming the entire Japan into a so-called "robot town" by bringing about a "daily life with robots" in society across Japan not only in industrial but also routine life scenes upon realization of robot revolution ahead of the world means that Japan succeed at establishing a platform status to win global competitions over various data obtained from real society.

(2) Need for strategies on global perspectives

Global trends in the manufacturing filed such as Industry4.0 and Industrial Internet are designed to create a next-generation production technology equipped with efficiency and flexibility through connection and control of various relevant systems. This is considered a part of competitions over object data in real society in terms of advanced control using AI of the key data collected and digitized from various conditions of business activities. In order for Japan as the global leader in production technology to continue leading the competitions over acquisition and utilization of digital data in this field, it is imperative to set up a advanced platform as a highly value-added production system and operate them globally.

Competitions will grow more intense over data in real society across fields beyond the scope of manufacturing in future. In order for Japan to strengthen competitiveness to survive such situation, advanced technology must be developed to lead the next generation while setting up a "robot barrier-free society" where robots are utilized in various fields at the same time. In addition, Japan should cooperate and collaborate with the world to set up global standards and various rules so that Japan can establish a platform to take full advantage of robots and make the most of data obtained from them as well as opening up a global market where Japan can exert its strength thoroughly embedded in the aforesaid platform.

In the course of above, robots must be positioned and employed not as a simple human replacement but as a collaboration and supplement partner. To make the most of such structure, human must strive to enhance its inherent value for a transition into a field of higher added value while improving the robot-operation system. The robots must be operated under a collaborating system with human where both parties supplement each other to draw an upward spiral for improvement.

As proposed above, measures for a data-driven society are more extensive focused mainly on robots while considering several factors across industries including supply chain management and marketing. These measures must be developed into a social reform movement through informatization towards the future in various fields of mobility, healthcare and energy. In the course of these initiatives, extensive collaboration must be made with the Council for Science, Technology and Innovation or Industrial Competitiveness Council including reflection on the 5th Science and Technology Basic Plan (Provisional translation) in order to accelerate discussions by the entire government.

Part II Action Plan: Five-year Plan

Chapter 1 Cross-Cutting Issues

Section 1 Establishment of "Robot Revolution Initiative (RRI)"

In order to make Japan as No.1 robot innovation base in the world and integrally promote and maintain the structure and environment to continuously develop robots that lead to a social revolution, "Robot Revolution Initiative (RRI)" will be established to serve as the center for wide-ranging stake holders who will clarify issues that they should work on by themselves, share progress status, and work together to specifically promote Japan's Robot Strategy.

RRI will share not only the implementation status of the government policy but also the status of actions of extensive stake holders concerned, and implement necessary improvement.

(1) Primary functions

1) Promotion of matching such as needs and seeds and development of solutions

RRI will maintain venues to promote innovation such as a forum to promote matching of related parties including manufacturers, system integrator (SIer), users, financial institutions, universities and research institutions, and related academic societies and perform environment maintenance, introduction of fund provision, and consulting so that these related parties can realize joint development or technical cooperation among them.

In addition, RRI will request users to present challenges and issues concerning robot utilization, extract technical challenges to truely fulfil the needs of users, and lead to important development in manufacturers, universities, and research institutions.

Moreover, as a premise for such efforts, it is necessary to encourage development and introduction through markets, by sharing specific contents of user needs and market size.

2) Strategic planning and utilization of international standards and security measure

RRI will promote international standards to realize robot revolution, such as planning and diffussion of international standards concerning the next-generation production system utilizing robots, intercountry collaboration to promote module-type robots in Japan and overseas. In order to accelerate specification proposal to the venues of international review and preceding discussion among related parties in Japan, RRI will establish a venue for review to promote standardization activities in the field of robots

Assuming that robots will play a major role in autonomic accumulation and utilization of data while in collaboration with one another, RRI will examine the establishment and maintenance of rules on security of robots.

3) Sharing and diffusing best practice

Efforts of advanced robot utilization are already underway in some fields and areas. Revolutionally and versatile examples of robot introduction will serve as potent tools to encourage robot introduction in other fields; therefore, RRI will collect and share widely the examples of introduction served as the best practice to encourage the diffusion and introduction of robots, thereby contributing to the realization of society where robots are difussed throughout Japan in every corner of daily life.

4) Planning of international research projects for international deployment of Japanese robots. US-Japan joint development of disaster responding robots, etc.

RRI will support the establishment of a structure in carrying forward joint researches, etc., that will contribute to the realization of robot revolution. RRI will collect internal and external information, organize research consortium through the provision of venues for matching, and organize and examine cross-cutting issues on robot research aiming to set up concrete project like US-Japan joint development of disaster responding robots.

Furthermore, RRI will plan and prepare for the holding of Robot Olympic (tentative name) and examine how to collect Japanese and overseas participants with cutting-edge technology (See Chapter 3, Section 7).

5) Proactive use of research and development institutions in Japan and utilization of alumni

The National research institutes such as National Institute of Advanced Industrial Science and Technology (AIST) and the New Energy and Industrial Technology Development Organization (NEDO) provide technical guidance to participants in RRI. Rejuvinate local companies through collaboration with universities and research institutes in each area.

RRI will also conduct personnel development in collaboration with educational institutions.

Section 2 Technology development toward the next generation

(1) Background

Processing capability of computers is advancing in an exponential fashion according to the Moore's Law. There is a view that one computer will exceed the processing capability of a human brain in 2020 and the intelligence of the entire human beings in 2045. It is anticipated that such advances in processing capability of computers will drastically enhance robot's ability to think in the future.

However, even if robot's ability to think enhances, robot's performance as a whole will not advance without improvement of element technology such as way of thinking, physical capability, and perception of robots as well as the base technology integrating them. Therefore, in order to achieve a drastic advancement of robot's performance as a whole, it is necessary to advance element technology of robots.

Meanwhile, another important perspective is to enhance processing efficiency through cooperation between humans and robots on the premise of input from humans according to situations, instead of aiming to solve all problems with the technology of robots alone.

If such robotic element technology and cooperation between humans and robots advance simultaneously along with progress in coordination among data terminals, networks and cloud services, it may not only result in the enhancement of labor productivity and resolution of labor shortage but also a revolution in the industrial structure itself.

(2) Basic philosophy

In order to fully benefit from exponential performance improvement of computers in fast-changing fields of robots and artificial intelligence (AI), it is necessary to promote research and development to win in the data-driven society through the realization of cooperation between humans and robots after understanding the trend and levels of robot and AI-related technology in Japan and overseas. In addition, in order for important element technology to achieve these, it is necessary to promote research and development of innovative next-generation technology. At that time, it is important to continuously share the final, innovative, assimilated "exit" image in addition to individual technologies by utilizing not only the technologies of the field that has been studied as the core robot technology but also technologies of other extensive fields. These research and development will be promoted effectively and efficiently in cooperation with Council for Science, Technology and Innovation.

(3) Technology that should be developed

Since various element research and technology are unified in robots and AI, related research and technology fields are very broad. Important element technology that will be actually used in industries and the society and can significantly impact them include artificial intelligence; sensor and recognition system; mechanism, actuator and their control system; software such as OS and middleware; core technology and base technology such as safety evaluation and standard; and technology converted from other broad areas. The following are the examples and issues of element technology.

1) Artificial intelligence (AI)

Technology required for robots to think and act according to instructions from people or the situation in the surroundings. Since processing capability of computers is advancing exponentially according to the Moore's Law, what can be realized with AI technology has dramatically expanded. However, there are following challenges at present:

- ✓ Although it is possible to provide one answer to one question based on given information, it is difficult to give a natural response based on the analogy of the context of conversation or instruction or by reading between the lines, or respond to unknown situations (machine translation is still developing).
- ✓ Pre-programmed movements can be made, but it is difficult to autonomous change or determine tasks by recognizing task progress or situations in the surrounding, or make a movement by imitating the craftsmanship.
- ✓ It is necessary to study modularization of AI and software (e.g., thinking system and reflex system in the brain structure) in terms of concentration of research and development resources and improvement of development productivity.

These challenges will require advancement and unification of data-driven AI and knowledge representing and reasoning AI (e.g., technology to realize analogy and reading between the lines of unknown conversation through learning to read between the lines from a large amount of conversation data, or to realize autonomic deduction of optimal movement by checking existing knowledge against the current situation), research and development of such technology as brain-like AI (e.g., development of advanced intelligence that imitates information processing in the brain by modularizing AI that imitates the regions of the brain such as a cerebral neocortex model, a hippocampus model, and a basal ganglia model and by combining them).

2) Sensing and recognition technology

Technology to import information concerning the situation in the surroundings into robots. Thanks to advances in semiconductor technology, sensors themselves are becoming less expensive and smaller, realizing easier utilization in terms of quality as well as quantity. However, there are following challenges:

- ✓ It is difficult to differentiate partially-hidden objects (occlusion) or objects whose outline cannot be cut out.
- ✓ Objects cannot be recognized in specific environments such as backlight and darkness. Images need to be processed faster than the traditional speed at the time of automatic movement in a narrow space.
- ✓ It is difficult to use a sense of smell to identify the location of a human body at disaster sites or pick up necessary sound from noise.
- ✓ It is difficult to identify specific voice when several people are talking simultaneously.
- ✓ It is also difficult to recognize various objects such as soft objects using a sense of touch.
- ✓ It is necessary to recognize surrounding environment according to situations in a flexible manner (even without a map) by unifying multiple data of surrounding environment indoors as well as outdoors.
- ✓ In order to recognize someone's will and feelings, it is required to presume by sensing brain waves, blood flow, and pulse in addition to movements and language.

These challenges require research and development of environment-learning vision sensor, voice processing and recognition technology under low signal noise ratio, smell sensor, distributed touch sensor system, and sensor fusion system integrating these sensors.

3) Mechanism, actuator, and control technology

Technology for robot's devices (e.g., motor, arm) to act externally. The power weight ratio (PWR) of servomotors has now become 5 times greater than that in 20 years ago, realizing an error of a few μm as movement accuracy. However, there are following challenges:

- ✓ It is difficult to realize both power (output) and dexterity (movement accuracy) with the same size and weight as humans.
- ✓ The current mechanism with high stiffness and actuator with little flexibility are not suitable for flexible movement. Meanwhile, artificial muscle is not suitable for accurate positioning.
- ✓ It is necessary to handle objects that humans use daily, such as objects of complex form

or flexible material, without obtaining information in advance.

- ✓ Modularization should be considered for manipulators and hands, instead of exclusive development as needed.

These challenges require research and development of servomotors with low-cost and high power weight ratio (PWR), multi-degree-of-freedom actuators imitating the human joint, high-molecular light-weight artificial muscle and a control theory for smooth control of such a highly non-linear system, and general-purpose hand system for bilateral control.

4) OS, middleware, etc.

In order to make a robot and robotic system, element technology, parts, and the robot itself need to be integrated using basic software such as OS and middleware. This will enhance compatibility and development productivity. These technology have following challenges:

- ✓ It is currently necessary to have the development and integration environment and tools to concentrate resources on the development of high-level applications for recognition, reasoning, and autonomic control (e.g., simulator to check movement of software without actually creating and using a robot; OS, middleware, and programming language that are easy to use and standardized to some extent) correspond to the future development of element technology.
- ✓ Interface of robots and modules needs to be standardized when robots with different OS communicate with each other, or a new module is implemented on a robot.

These challenges will require research and development of simulators simulate working environment, and OS and middleware that can work with simulators, as well as general-purpose OS and middleware that can be used as the standards.

5) Security and safety evaluation and standard

Technology and techniques are required to create robots and securely and safely diffuse them. These technologies have following challenges at present:

- ✓ The current technique is insufficient in identifying and evaluating the risk of unexpected potential accidents that result from the expansion of the area to utilize robots.
- ✓ It takes time for studies of subjects for safety, etc. (including administrative response).
- ✓ Rules for the protection of personal information collected by robots and personal information collection by robots (e.g., photo taking) are not examined sufficiently.
- ✓ People's acceptance of robots needs to be enhanced through the enhancement of human

interface.

- ✓ There is a security risk that commingling of a malicious program may cause malfunctioning of robots or unintended data leak.

These challenges require techniques for safety evaluation and risk prediction, establishment and standardization of test methods, rules for handling information collected by robots, and examination and research and development of security technology.

In addition, technologies converted from broad fields other than the above have following challenges:

- ✓ Light-weight and long-lasting energy source (e.g., battery) will be required.
- ✓ As it is heavy, it requires power to move (if the weight of the frame can be reduced, the size of actuators such as a motor can be reduced, resulting in further weight reduction and a favorable cycle). If the robot itself is heavy or has heavy arms, it is dangerous as it cannot stop immediately and causes a great impact when it runs into something.
- ✓ It is necessary to remotely control robots without distant restriction (radiowaves do not reach or cannot be used depending on sites) or autonomously coordinate multiple robots. (e.g., high-speed / ad-hoc network technology, tele-operation/autonomous exploration technology for ocean resources exploration)
- ✓ It is necessary to make robots to grasp their own present locations and the situation in the surroundings such as the presence of obstacles, through the maintenance of the environment to provide highly accurate location information with the use of satellite positioning and sensors.
- ✓ Shield mechanism, heat-resistant materials, and corrosive-resistant materials for operations under extreme environments such as in water, high-temperature environment, and toxic environment, need to be converted or improved from those used in other fields.

These challenges require research and development of long-life, compact and light-weight battery technology, wireless electricity supply technology, communication technology, and material technology.

4) Ideal situation of research and development

In an early stage, it is necessary to research and develop many element technologies in parallel to technology requiring continuous long-term research and development as well as technology requiring to achieve short-term research and development results. In addition, promote competition among different technologies by cooperation and information sharing among different technology through holding of workshop by research institutions such as

NEDO, AIST, and National Institute of Informatics (NII) as needed, and promote inter-technology competition by utilizing the award (competition) system such as challenge programs, and facilitate research and development with the introduction of open innovation. (It is possible to conduct research and development oriented for issue-solving by maintaining the venue for cross-cutting research development and collecting leading researchers depending on fields and contents of research.)

Among element technologies for research and development, promote element technologies which should be put into practical use by 2020 and 2025 by using the planning and operation of DARPA[9] project with innovative and non-continuous targets (e.g., targets such as one-digit higher performance, one-digit lower cost). Specifically, program manager (PM) will specify important element technology as the second-generation technology and concentrate investment on the technology. Establish a stage gate midway through research and development so that narrowing down of promising technology and review of implementation structure can be flexibly performed based on PM's judgment.

In addition, in order to lead them to practical use quickly, integrally promote the standardization such as environment maintenance and data format, including the review of laws and regulations and social systems along with the review of technology diffusion and business strategy. Proactively utilize systems such as the special district system for the verification toward the practical use of new technology.

Universities and research institutes are expected to play a large role not only in the field of application but also in basic research. Universities are particularly expected to promote the systematization of robot technology, which is rapidly developing in collaboration with various fields, as an academic field that will serve as the base of research with an overview and future perspective.

9 At the Defense Advanced Research Projects Agency (DARPA) of the U.S. Department of Defense promoting non-continuous innovations concerning national defense in the U.S., PMs are given substantial authority and discretion. With the stage-gate system, narrowing down of promising technology and review of implementation structure can be flexibly conducted based on PM's judgment. As a result, they effectively utilize new and novel ideas and technology such as venture companies and effectively carry forward high-risk, high-impact research and development, the mission of DARPA

<Related measures and policies>

◇ *Development of core technology of next-generation robot (The Ministry of Economy, Trade and Industry)*

- *Develop core technology for robot element technology that is necessary but not yet developed. In addition, research and develop common infrastructures including various techniques and technology such as risk and safety assessment methods and security technology.*

Section 3 Policy on the Global Standardization of Robotics

If Japan's robots hope to be used all over the world, it is important that our robots are not an isolated system, but one with compatible hardware and software with connectible interfaces on top of a common infrastructure.

It is also important that we establish internationally compatible regulations and a framework for the widespread use of robots the world over so that once the necessary domestic requirements are met, Japan's robots would be able to be used anywhere in the world.

Therefore, we should take the lead to promote internationally accepted standards based on the strength of our technology and at the same time advocate further domestic standards to promote the use of robots in Japan.

Subsection 1 Common Infrastructure with a View Towards Modularization of Hardware and Software

(1) Background

One of the objectives of the robot revolution is to induce change in Japan's economy, industry, and the lives of its citizens by finding new areas of application for these instruments to boost productivity, free the workers from the hardship of excess labor, and resolve labor shortages.

Although there are many areas and applications for robots in manufacturing, the service industry, agriculture, and construction, the rate of automation by robots in welding, painting, and assembling and mounting standard parts is still low in large-scale factories. In areas other than industrial robots (i.e., service robots), robots have yet to gain a foothold in term of their use and popularity partly due to the lack of a "killer application" that would satisfy the needs of its users and resolve the issue of high prices and difficulty in maintenance.

One of the ways to resolve these issues is a strategy to promote modularization, the utilization of middleware or operating systems for robots, international standardization, and the creation of a common platform.

(Middleware and Operating Systems for Robots)

Since conventional robot systems are often built with hardware and software unique to a specific task, a large fraction of the parts and the software cannot be reused. This in turn raises the cost of not only the hardware but the software that controls the robots.

Common parts could be utilized in a wide variety of robot systems if the functional elements of a robot could be modularized and common parts of its hardware and software shared. In this way, a robot could be constructed at a lower cost. Moreover, by using a common software platform, a variety of functions necessary for the robot can be installed into the platform while the robot integrator can focus its attention on achieving a specific designated function.

(Standardization)

In order to realize such mechanism, standardization and commonization of interfaces between components both software and hardware produced by different manufacturers are indispensable.

In the past, the de facto standard established by a handful of dominant corporations prevailed. However, de jure standards such as the ISO have gained ever more importance as the level of technological complexity has progressed. This has made de facto standards more difficult to establish as interest in the creation of international standards has grown in the rest of the world. In contrast with the past when a standard was determined once a product was put on the market, European countries are taking a longer term perspective by incorporating standardization into their planning at the R&D level in cooperation with corporations, academia, and research institutions. They have employed a strategy to establish standards, which has given the region's corporations an international advantage.

Europe provides a case in point in that it is no longer sufficient to merely improve common parts accessibility, but to establish a national strategic perspective of securing the international competitiveness of our corporations involved in robotics and to lay a foundation that will lead the robotics industry into the next generation. As in Europe, it is important that Japan tackle the issue of standardization that is integrated to and in parallel with its R&D efforts.

(Platform)

Recently in the field of information technology, a variety of "cloud" services are increasingly being offered on the internet server with the individual users using their terminals to merely request and receive services.

In the field of robotics, there is also a trend to connect a variety of devices to the internet to offer a multitude of "cloud" services. Businesses that offer a cloud service platform are able to gain access to the user's request and terminal information, (i.e., the so-called big data) which enable them to use this data to hone their business strategy, refine their products and services, and provide effective support, advertisement and recommendations with the potential to further build their customer base and expand their businesses. It is evident that to succeed in the next generation of the robotics market, establishing a platform and capturing big data is crucial.

(2) Specific Examples

(Middleware and OS for Robots)

Given that robots are systems that physically interact with the real world, robots need to be operated with OSs (operating systems) different from that of a regular personal computer. Additionally, recent robot systems require a certain degree of coordination with a variety of sensors and other robots connected to the internet. OS for robots and middleware are the tools that offer such functions for these robots.

Examples of such middleware are ORiN (a specification established by a council consisting of major robot manufacturers in Japan), which provides common interfaces to access conventional industrial robots; the RT-Middleware, which is an open source development project promoted by the Ministry of Economy, Trade and Industry projects; and V-Sido, a development started from the so-called “the MITOH Project (the Exploratory IT Human Resource Project)” By IPA. A variety of other OSs and middleware have been developed recently, such as ROS as well as OROCOS and YARP.

(Standardization)

A number of standards have been established for robots and mechanized systems for manufacturers such as IEC 61131 (standard programing specifications for PLCs), IEC 61158 (fieldbus-related standards), ISO 15745 (an application integration framework), and ISO 15704 (a device profile). Technological progress has provided us with new communication devices, protocols, control devices, and robots. Manufacturers have also ratchet up their efforts to establish their products as the international standard.

Germany’s Industry 4.0 has recently been a focus of attention. This is an attempt to significantly improve production and sales efficiencies and production flexibility by capturing not only a company’s management and production system, but all information along its value chain and integrating this on a computer. Standards have been established to integrate such business and production management with actual production management systems such as ISO/IEC 62264.

The only standards currently available to robots are ISO 10218, which is applicable to industrial robots and robot-related devices and ISO 13482, a recently established safety-related standard for service robots. Moreover, the aforementioned ORiN interface standard for industrial robots is referenced as an administrative example of ISO 20242-4. The modular interface for RT-Middleware was standardized by the OMG (Object Management Group), an organization to promote the standardization of software. Other examples of standards under discussion include a standard for robotic vacuum cleaners, IEC TC59/WG5, a safety standard for cooperating robots, ISO TC184/SC2, a safety standard for robotic devices for nursing care (WG3), and a modularization of software and hardware for robots that move on wheels (WG8). In Japan we should be prepared to commit to these standards guided by a defined strategy or actively promote the universal application of these standards.

(Platform)

There are a number of variations to what are called platforms for robots. One of these is the software platform that runs robot applications and forms the basis of its sales. For instance, there is NAOqi, which is used on Softbank's Pepper developed by Aldebaran Robotics; the RT-Middleware, an OS and middleware for robots; and ROS, ORiN, and V-Sido are examples of such platforms. Cloud can now also be considered as a platform offering a universal form of service to its customers. KOMTRAX offered by Komatsu, the database function equipped on PLCs offered by Omron, the UNR platform used by service robots, and RSi may be classified as cloud based platforms. M2M (machine to machine: a method to improve production efficiency by facilitating the communication between machines and the exchange of information) and IoT (internet of things: a technology and infrastructure that allows objects to obtain information via the internet and control them at will) have also not only recently been implemented on an individual basis, but the infrastructure of such services are in the process of being offered. These examples can also be considered as forms of robots.

Robot hardware can also be considered as a platform. Softbank's Pepper is a platform in so far as it is equipped with a variety of service applications. There is also the HRP-2 which was first created as a platform for a research robot under MITI's Humanoid Robot Project, which then evolved to S-ONE under SCHAFT Inc. (awarded first place in the DARPA Robotics Challenge for rescue robots and subsequently acquired by Goggle).

In both examples, a variety of software, applications, customer information, data information regarding the product, and ultimately the customer and robot hardware itself have been assembled onto this platform. These elements are assembled by corporations that possess a platform containing such valuable functions and services. Since a positive feedback occurs where more information is gathered by increasing one owns value, it is important to form different platforms in a variety of fields

(3) Our Vision for 2020

The creation of an OS and middleware for robots and the variety of related interfaces, the standardization of data in addition to a variety of different platforms, which are all necessary if Japan is to lead the coming robot-led industrial revolution, are beyond the scope of any individual company

As such, the active promotion of an OS and middleware for robots, which constitute the core of controlling the robot, is crucial if we are to foster the creation of an industry for the next generation.

The applications that run on an OS and middleware for robots and the variety of sensors necessary in a module, an area at which Japan excels, as well as the robot and software vendors should always follow and conform to the specifications determined by the OS and middleware of the robot. Furthermore, since the OS and middleware of the robot directly controls the robot and plays an important role in its safety and security, an involvement by a public institution (in the form of authorization or certification) is necessary from the perspective of product safety.

A wide variety of robots can be produced efficiently and at low cost by the year 2020 if such an environment to certify robots is facilitated. Robots that have received some form of certification to assure safety and security from the perspective of user protection should become more accessible to the public helping to improve productivity and our quality of life. Japan could be a world leader in the robot industry if the country were to take the lead in establishing various international standards that would allow our domestic hardware and software to retain its international competitiveness.

If such a goal were attainable, it is imperative that Japan establish a clear strategy towards a common OS and middleware or platform together with the standards to which they conform. Standardization should be pursued within a framework of cooperation between industry, academia and government. In doing so it is important that attention is given to not only crafting middleware and networking from the robot's perspective, but to take a broader view under the premise that robots will be used in conjunction with machine tools and carrier equipment other than robots.

In order to achieve this vision, the forthcoming "Council for a Robot Revolution Initiative" (see Subsection 1) should act as the control center in gathering necessary information and communicating its position to the rest of the world and take the lead in forming international standards.

Subsection 2 Building an Internationally Coordinated Regulatory Framework (Japan-EU Regulatory Cooperation)

(1) Background

Given their frequent contact with people, life supporting robots require a high degree of safety. However, safety standards have not been yet established. There also exist high hurdles for their practical introduction to users. Product development risk on the part of corporations was also significant. Given these obstacles, a resolution was passed during an international conference in 2006 to hold an international discussion on the topic of international standards regarding life supporting robot safety. Subsequently, an international standard regarding the safety of life supporting robots went into effect in February 2014 led by Japan, which has been a pioneer in the development of life supporting robots.

ISO13482 has become the standard for life supporting robots excluding medical use. Its corresponding CE marking (a certified seal mandatory for manufacturers wishing to market their products within the EC markets) has been recognized as the harmonized standard under Machinery Directive (ISO13482 EN).

However, there is a possibility that confusion may arise for manufacturers in obtaining a CE marking in the EU since some life supporting robots may not be recognized under certain operational rules as a machine, but as a medical device.

Therefore, discussions concerning regulatory cooperation will be held between Japan and the EU to facilitate manufacturers in obtaining a CE marking in the EU.

(2) Specific Examples

Japan and the EU will discuss the concept and underlying thought process with regard to defining the difference between a “machine” and a “medical device” as it pertains to life supporting robots in the EU. Both parties will also establish guidelines to provide some degree of predictability to concerned parties in obtaining a CE marking for life supporting robots.

(3) Our Vision for 2020

After the Japanese manufacturers of life supporting robots are domestically ISO13482 certified, there should be an environment where a CE marking can be readily obtainable. We should be able to benefit from life supporting robots not only in Japan, but in a variety of applications all over the world to help us address the many social issues of our times, such as the aging population, lower birthrates, and labor shortages.

Subsection 3　Standardization to Promote the Use of a Network for Robots

(1) Background

As M2M and IoT progress, robots will be connected over a network such as the internet allowing robots to cooperate with each other, allowing artificial intelligence to control robots remotely, allowing the management and utilization of data on cloud, and other ways conceivable. On the other hand, regardless of the robot’s purpose or usage, or the differences in hardware applications, among the various functions such as sensing and AI, it is important for the early practical application of robots that we establish a needed common function (a “common platform”) to promote the usage of a network for robots.

Therefore it is necessary that we establish a number of standards regarding a common platform to create a network for robots.

(2) Specific Examples

The International Telecommunication Union (ITU) has been responsible for standards, led by Japan, to set required conditions and functional requirements for the use of a network for robots. We expect they will continue to contribute to the expedient creation of such standards. In addition, we should be prepared to actively participate in the planning stages of a communication protocol that would enable robots to talk with each other or standards regarding the technology to control multiple robots, which are currently underway at the U.S. Institute of Electrical and Electronics Engineers, Inc. (IEEE).

(3) Our Vision for 2020

We predict that a wide array of products which we use daily, such as cars, electrical appliances, and mobile phones will have some robotic features and more than ever linked to the internet. We also expect that a wide range of information generated from these robotic devices will be accumulated, analyzed, and utilized as big data via systems such as M2M and IoT further expanding the possibilities of robots and contributing to the improvement of our daily lives and resolving social issues.

As for the utilization of the internet by robots in the era of the “robot revolution,” we should take the lead in establishing various standards concerning a common platform by capitalizing on our experience and predominant position in this field. We should also capitalize on our actual past use and application experience to be a front-runner in conceiving new applications for robots and to retain our predominance in the world robot market.

Section 4 Field-Testing of Robots

(1) Background

The future goal of the “robot revolution” would predict a society where robots are widely used in all aspects of our lives and solving some of our social issues. If that is the case, robots can only attain their raison d’être if they are actually utilized on the ground.

This view suggests that during the final stages just prior to its practical application, an important process would be to make final adjustments by conducting field tests under the same conditions as its intended purpose

Conversely, there can be a wide number of problems that may occur which could never have been predicted during their practical application. If we are to have highly sophisticated robots in society, it is necessary that we conduct comprehensive field testing to assure their safety. At the same time, we should create a setting to verify and improve the “user-friendliness” of robots.

In order to accelerate the development of robots and their introduction into society, aside from support for their technological development and introduction, we should consider the merits of a testing site to field-test robots in order to bridge development and their practical application.

(2) Examples of Present Testing Sites for Robots

The following testing sites exist in Japan utilizing the special zones for structural reform or offered by local governments that provide a flexible environment to perform field-testing for a relatively wide range of purposes:

◇ Promotion of the development and introduction of the next generation of infrastructure robots (MLIT’s field)

- Conducts testing of robot technology for bridges, tunnels, under water maintenance, disaster inspection, and emergency disaster recovery under the auspices of the Ministry of Land, Infrastructure, Transport and Tourism

◇ Testing support at the Sagami Special Industry Zone for Robots (Kanagawa Prefecture)

- Supports field-testing by public invitation to corporations by offering a pre-testing site and conducting tests for life supporting robots used in nursing facilities utilizing old schools which have been closed.

◇ Hyogo Prefecture Wide Area Disaster Management Center (Hyogo Prefecture)

- Trains personnel specialized in disaster prevention and leaders specializing in regional disaster prevention. A facility designed to function as a center for wide area disaster management in times of duress. Also functions as a testing site for disaster response robots.

◇ Safety Testing Center for Life Supporting Robots (Tsukuba City)

- Supports 18 varieties of tests such as running tests, human interaction tests, durability tests, EMC tests, etc. for the purpose of obtaining safety certified life supporting robots (under ISO13482, etc.).
- Already four different robots have been ISO13482 certified using this facility.

(3) Example of an Overseas Facility Available for Robot Testing

The following facility is available as a site for robot testing:

◇ TEEX Disaster City (Texas U.S.A.)

- A training facility for the purpose of emergency response and improving the skills of practitioners
- An arm of the Texas A&M University established in 1997 consisting of the Brayton Fire Training Field and the National Emergency Response and Rescue Training Center. The 90-95% of the operating costs of about 8 billion yen a year is appropriated by the facility use fee.
- Approximately 80% of the facility is used for fire-fighting and 20% for military use and a small fraction for use by petrochemical-related companies.

(4) Our Vision Concerning the Creation of Robot Testing Sites

As we contemplate the functions of our present robot testing sites, we should compare them with what is being done at similar sites overseas and support the testing efforts conducted independently at private corporations and universities. We should also consider expanding existing facilities or constructing facilities with new functions as deemed necessary.

At the same time, it is important that we set as our goal to create a site that will foster future innovation. We envision a site where challengers of the robot revolution can gather from around the country and abroad, and by offering an appropriate testing environment, assure their safety and the improvement of user-friendliness. The following are items which we feel are important if the continued use of these robot testing sites are to endure into the future:

1. Assure sufficient physical space for robot testing and freedom from existing regulatory constraints by utilizing the system of special zoning
2. A facility which serves the needs of the public and can also support a sufficient amount of demand from the private sector
3. The test results derived from these test sites should produce a concrete and institutionally significant effect that may lead to future commercialization contributing to further deregulation, public procurement, obtaining certification and such.
4. The site is part of a specific and stable administrative organization such as a university or local government.

Such efforts should be promoted further together with an objective of establishing a development center for robots suited for a wide range of applications whether it be on land, sea, or in the air. This development center will be located in Fukushima Prefecture and called the Fukushima Hama-Dori Robot Testing Zone (provisional name) as a new testing site to accelerate the practical application of primarily field robots.

Section 5 Human Resource Development

(1) Background

In order to broaden the range of robot utilization toward 2020, human resources with knowledge of robots will be required in various scenes. In particular, in addition to human resources that engage in research and development of robots, those that will be the key for robot utilization, such as those for software and SIers, are expected to further increase their importance.

Besides, in areas where robots have not been actively utilized so far, it is necessary that people who are in a position to actually collaborate with robots should newly acquire knowledge and usage know-how about robots, and measures to deal with it need to be investigated.

In considering robot utilization for the future, it is necessary to develop human resources that have not only knowledge about robots themselves but also comprehensive knowledge covering related areas such as IT. It is important to consider measures required to achieve that end from various viewpoints and to take actions.

(2) Future actions

In considering the urgent issue of how to develop and secure SIers, in particular, human resources that can actually design operational processes or systems at workplaces where robots are utilized, in relatively short period of time toward 2020, various ways are conceivable. For example, to develop human resources by having people accumulate experiences at workplaces (OJT) and to make use of retired workers in arears where human resources are likely be insufficient for now. Another way is that from the viewpoint of making use of limited human resources intensively in short time, an SIer and a user company establish a joint venture to proceed system construction together to promote know-how accumulation and human resources development.

In particular, regarding OJT-type human resource development, it is expected that effective results can be obtained by setting up a mechanism that provides an incentive to businesses, such as linking to a budget project such as a demonstration project for introduction to workplaces.

(Measures to be taken)

◇ *Development of SIers by utilizing "Demonstration Project for Robot Introduction" (METI)*

- *To have SIers accumulate experiences and achievements to develop them on an OJT basis by designing the scheme of the demonstration project for robot* *introduction and the feasibility study such that SIers play a central role as the implementing entity of support projects, and the like.*

Furthermore, it is important to promote basic and fundamental research based on needs. In conjunction with this, it is essential to develop human resources of the next generation who will perform the development of robots in Japan. It is particularly important to develop SIers that combine technologies and human resources that promote practical application and commercialization. In addition, necessary measures should be implemented to raise the level of utilization know-how at workplaces.

For that to happen, it is important that educational institutions, such as research institutions and universities, should newly consider the introduction of interdisciplinary curriculum concerning IoT and the like. At the same time, they should develop human resources through the implementation of attractive projects that allure young people and develop humans and technologies together, as well as those that not only engage in research and development but also venture into starting a business and the like.

Also, it is necessary to consider measures for developing human resources that understand technologies, principles, operation methods and the like about robots at workplaces by utilizing public vocational training for employed workers, certification and qualification systems of not only robot manufactures but also robot users.

Furthermore, toward the realization of "society where robots are part of daily life", it is necessary to cooperate with educational institutions and social educational facilities such as science museums and museums as well as to make children well equipped with knowledge about robots from their primary or secondary education stage and to make them familiarize themselves with and use robots in daily life.

(Measures to be taken)

◇ *Utilization of public vocational training for employed workers.*

- *In order to improve technology and skills of human resources such as SIers, the Ministry of Economy, Trade and Industry and the Ministry of Health, Labour and Welfare coordinate on the consideration of the utilization of public vocational training for employed workers.*

As for medium- and long-term human resource development, it is necessary to firmly identify the method that enables to appropriately and efficiently develop human resources at each stage and area and to ensure that these development measures work in conjunction with each other.

(Measures to be taken)

◇ *Part of Program for Creating STartSTart-ups from Advanced Research and Technology (START)*

- Promising technologies, including robotics technologies, are explored from university researches,under a R&D program that supports commercialization of innovative technology with management of human resources from private sectors, who have commercialization know-how.

Section 6 Implementation of Robot Regulatory Reform

(1) Background

When introducing robots into a society, it is required that robots should conform to existing laws and regulations to which they will be related. In the case where such laws and regulations are considered inappropriate in the light of socioeconomic circumstances and existing laws and regulations, it is required to streamline regulations such as amendments to laws, authorization of special zones, and establishment of new laws.

For example, in the case of Radio Act, possible measures include the establishment of rules aimed at robot utilization such as frequency allocation and regulate maximum permitted power, and in the case of Road Traffic Act and Road Transport Vehicle Act, the sorting-out of legal position of vehicles equipped with robotic functions. Also, many laws and regulations for consumer protection are related.

Japan is one of the world’s leading robot superpowers, and its technical advantages still remain. However, Japan is now being caught up by foreign countries such as USA, Germany, and China, and in order to accelerate the introduction and utilization of robots all over Japan, it is essential to promote regulatory reforms that are well-balanced in both of deregulation and rule establishment aimed at robot utilization as well as to create rules to assure the safety of robots from the viewpoint of consumer protection.

In the past, efforts have been made in both of deregulation and the establishment of rules concerning safety standards, such as mitigating the 80W restriction in Industrial Safety and Health Act to enable collaborative work between humans and robots without being enclosed by fences as long as certain conditions are fulfilled and providing the system in which the safety certification in compliance with the international standard can be obtained after ISO13482, which is the international safety standard for life support robots, took effect. In the future as well, while making effective use of rapidly progressing robots in Japanese society, regulatory reforms will be aggressively promoted so that Japan can become the world-class show case of robot utilization.

(2) Issues in regulatory and systemic reforms and action plan toward 2020

Considering the period up to 2020, it is necessary to identify the occupational field and domain in each area where productivity improvement can be achieved by introducing robots and to establish the environment (semi-standardized environment) in which robots can demonstrate their abilities. As part of such activities, the reform of regulatory system with respect to robot utilization is an important issue, which is divided into two: 1) deregulation and establishment of new legal system and utilization environment to make effective use of robots; 2) establishment of the framework required from the viewpoint of consumers. Issues to be concretely dealt with and action plans are organized as follows.

To promote regulatory and systemic reforms, it is also necessary to promote the international harmony of regulations and systems on the assumption that they are reciprocally applied both home and abroad, such as explosion-protection standard on robots.

Also, aiming at opening the possibility of new robot utilization that will lead the world, issues are sorted out at any time to promote necessary reforms with “Robot Revolution Initiative” playing a central role. At that time, cooperation is made with Council for Regulatory Reform of the government to promote comprehensive reform in which the related systems are looked down. Furthermore, the reform should be promoted with close cooperation with the research and development of hardware technology and software technology of robots that can be utilized under the established environment to accelerate the construction of a robot barrier-free society.

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

(i) Establishment of new radio wave utilization system that supports robot utilization

As seen in robot operation (control), transmission of image data and the like from robots, and sensing for robot detection of obstacles, the utilization of radio wave in robots is different from existing versatile forms of radio wave utilization. For this reason, the rules are to be created as a new system of radio wave utilization.

In this rule creation, it is appropriate to determine technical conditions, such as frequency band and power, suitable for radio wave utilization by robots, by trying to achieve frequency sharing with existing wireless system and the like, while considering the utilization form and utilization environment and based on the understanding of the actual state of radio wave utilization in Japan.

Also, in radio wave utilization for the operation of uninhabited aerial vehicles, it is important to continue to consider international cooperation as well, based on the fact that the international consideration of frequencies for uninhabited aerial vehicles is being proceeded by International Civil Aviation Organization (ICAO) and International Telecommunication Union (ITU).

Note that in the Ministry of Internal Affairs and Communications, “Study group on radio wave utilization system for robots” has already started the consideration of establishing the environment for new radio wave utilization system to support such robot utilization.

(ii) The Act on Securing Quality, Efficacy and Safety of Pharmaceuticals, Medical Devices, Regenerative and Cellular Therapy Products, Gene Therapy Products, and Cosmetics

Regarding brand-new medical devices, including those utilizing robotic technology, such as surgical operation support robots that enable less-invasive and precise movement to reduce patient burden, it is aimed to accelerate the pre-market approval reviewunder the act. The targets of standard total review period from the receipt of application of brand-new medical device to its approval are to become 14 and 10 months for normal review item and priority reviewreview item, respectivelyrespectively.

(iii) Long-term care insurance system

Amid the increasing need for care devices utilizing robotic technology, it is necessary to accelerate their diffusion by providing appropriate support for developing companies and care workers.

To that end, regarding the item review of the long-term care insurance system, which is currently carried out once in three years, the system for request receipt, consideration and the like should be made flexible to be able to rapidly deal with technology innovation. To be more specific, requests regarding the coverage of the long-term care insurance system should be received anytime; current items that can be considered eligible should be promptly made known; the addition of new items should be decided at any time by holding “Evaluation Committee for Long-Term Care Insurance Welfare Equipment” and “Subcommittee for Long-Term Care Benefit Expenses at Social Security Council” when and as necessary, for example.

(iv) Road Traffic Act and Road Transport Vehicle Act

Research and development of mobility robots including electric personal assistive mobility devices has been rapidly progressing at home and abroad. If our country is to have an edge in international competition in the future, it is essential to further introduce new models through research and development and to get a broad range of feedback from the market.

However, under current laws and regulations, electric personal assistive mobility devices are classified as motor vehicle or moped depending on the total displacement or rated power, and they cannot be used on public roads unless the safety standards are met in principle. Once the safety is secured, they can be driven on public roads after admitted for relaxation of the standards in accordance with Article 55 of the safety standards for road transport vehicles (1951 ordinance of the Ministry of Transport, No. 67).

At present, public road demonstration experiments for electric personal assistive mobility devices are being conducted in the City of Tsukuba, Ibaraki Pref. by utilizing the special district system. Based on the evaluation results of “Evaluation and Research Committee for Structural Reform Special Districts”, which is planned to be conducted during FY2014, the way to deal with these assistive mobility devices will be considered, including whether to make use of “Special System for Corporate Field Tests”, which was created in 2014.

Also, regarding autonomous driving, efforts will be made based on the Public-Private ITS Initiative/Roadmaps, which was determined in the Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society (in June 2014), and in consideration of consistency with the Geneva Convention and the like.

Furthermore, under current laws and regulations, when unmanned farm machines such as driverless tractors go to farm land, they are not allowed to be used on public roads. The way to handle this issue will also be considered while sorting out the consistency with international agreements and conducting safety verification.

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

The expectation for uninhabited airborne type robots (UAV) is great in disaster sites and the like, and their diffusion is expected in the future. However, concrete operation rules for these robots have not been clarified. Therefore, regarding so called small-size uninhabited aerial vehicles, while identifying their operational situation, further examination will be proceeded including the necessity of rules to which public institutions are related and related laws and regulations.

As for the uninhabited aerial vehicles system (large-size uninhabited aerial vehicles) which fly by remote control internationally under IFR (Instrument Flight Rules), domestic rules will be established by participating the consideration of the revision of the international standards at International Civil Aviation Organization (ICAO) and based on such revision which is expected to take place in 2019 or later.

(vi) Laws and regulations related to public infrastructure maintenance and repair

In maintenance and repair of public infrastructure, human operations are assumed and “visual” inspection may be required. In order to further improve the effect and efficiency of maintenance and repair, based on the on-site verification results concerning infrastructure maintenance and repair and disaster-responses and the on-site demonstration results concerning the maintenance and repair of the infrastructure for port facilities, which were started in 2014 by "Next-Generation Social Infrastructure Robot On-Site Verification Committee", the effective and efficient utilization methods of useful robots should be determined.

(vii) High Pressure Gas Safety Act

In addition to the afore-mentioned public infrastructure, in industry infrastructure such as plants as well, it is necessary to establish robot utilization rules so that robots function as substitutes for humans with respect to inspection operations, such as visual inspection, which are assumed to be performed by humans.

To that end, technology development based on field needs and verification and evaluation using plants and the like should be simultaneously proceeded, and after clarifying the technology level required in the field, the system concerning the inspection by robots will be considered.

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

(i) Consumer Product Safety Act, Electric Appliance and Material Safety Act

Assuming a society where robots reach every corner of daily life and the utilization of next-generation robots related to daily life, which have autonomy and remote controllability, is expanded, it is necessary to strengthen measures for securing consumer safety. With respect to information collection and cause investigation when a serious product accident occurs due to robots, technical standards concerning equipment treated as electric appliances, and the range of responsibilities of manufacturers and the like, based on the trends of technology development and specific commercialization, it is necessary to consider treatment under the current system where robot utilization is not assumed.

To that end, based on the analysis of accident information and the like to be collected in accordance with current laws and regulations, necessary actions and measures should be considered.

Section 7 Expansion of Robot Award

(1) Background

It is undeniable that in encouraging industrial development, evaluating and honoring excellent cases exert a large impact. Awarded cases give a strong motivation to the daily activities of a broad range of the related people, and for the whole nation as well, they serve as a springboard for identifying trends of leading-edge technology and enable to proactively deal with such trends. For this reason, in the robot field as well, "Robot Award" has been implemented since 2006 (co-hosted by the Ministry of Economy, Trade and Industry and the Japan Machinery Federation), honoring robots that are high in contribution and expectation for future market creation.

In this project, 63 cases were honored by the sixth round, and various cases were taken up: not only major manufacturers of industry robots but also small- and medium-size start-ups having innovative element technology and user companies that solved problems using robots. The project has played a large role as a messenger to society.

Robot Award, which has accumulated achievements as seen above, should be developed to a framework to be enhanced by the whole government such that while the accumulation so far is utilized, the award becomes the driving force to further accelerate efforts by the related people toward the realization of robot revolution.

(2) Future direction

Currently, the application is accepted for the following five areas:

1) "Industry robot area"

Robot and system that are used in production sites such as factories

2) "Service robot area"

Robot and system that provide various service at office, home, public space and the like

3) "Public and special environment area"

Robot and system that operate under public and special environment, such as search and restoration in disasters and research in the sea

4) "Parts and software area"

Parts, material, or software that constitute part of robots

5) "Robot business/social implementation area" (newly established at the 5th round (2012))

Manufacturers, businesses, and system integrators who have introduced and use robots to realize the service and social implementation of robots, or human resources that played a central role in such cases

These areas will be flexibly reviewed and examined based on social conditions and technology trends.

Furthermore, based on the understanding that the Robot Award is extremely important as a platform to evaluate next-generation robots and advanced utilization examples and to encourage the participation of a broad range of related people, the establishment of new award categories by relevant ministries and the expansion of award coverage will be carried out one by one from the next round onwards from the viewpoint of rewarding excellent activities by the whole nation. And the Award will be developed into the one that can be backed up by the whole government including the consideration of the establishment of still higher award categories.

Section 8 Consideration of Robot Olympic (Provisional Name)

(1) Background

It was decided that the Olympic and Paralympic Games are to be held in Tokyo in 2020 for the first time in 56 years.

In the Olympic Games of 56 years ago, construction investment for the development of competition facilities and transportation network (such as subways, Metropolitan Expressways, and Shinkansen) increased, and furthermore, travel demand for seeing competitions expanded and the penetration rate of color TVs rapidly increased. As such, the Olympic Games acted as a trigger for big changes in society and people's daily life.

By making best use of a worldwide event, Olympic Games, the research and development of robots will be accelerated and their broad introduction and diffusion in the Japanese society will be promoted, and at the same time, there are potential that the Olympic Games function as a driving force of "robot revolution" in which people's daily life is changed by robots, and the Olympic Games offer a great opportunity to show Japan, which transforms its society ahead of the world as the achievement of the robot revolution, to the people who visit from all over the world.

By accelerating activities aimed at the realization of the robot revolution and bringing "daily life with robots" to all over the country in the year of the Olympic Games, the state of Japan, where the whole city is integrated with robotic technology, will be shown to the world as a robot showcase. In addition to this, based on the fact that the Olympic Games are a historical festival to strongly deliver the value of human's challenge to limits, it is worthwhile gathering the leading edge achievements of home and abroad concerning robots and providing an opportunity to tackle the challenge of reaching a further height.

(2) Concrete activities

As a method to accelerate the research and development of robots and to introduce and diffuse them into the real world, that is, to proceed the social implementation, competitions, verification experiments, demonstrations, that is, the Robot Olympic (provisional name) is to be carried out. It is not merely a competition to compete in robotic technology; instead, it solves actual issues in various areas, such as medical and health care, infrastructure inspection, agriculture, forestry and fisheries industry, manufacturing industry, service industry, and entertainment industry; it makes actually useful robots compete each other; and it shows to many people what robots are. The introduction and diffusion of robots will be promoted by making people feel familiar with robots and search how to solve real issues with robots, discuss their utilization methods, and think how to work and live a life with robots.

Concrete examples include the R&D and on-site verification projects for infrastructure inspection robots and disaster-response robots, which are being conducted by the Cabinet Office, the Ministry of Economy, Trade and Industry, and the Ministry of Land, Infrastructure, Transport and Tourism. In the projects, infrastructure inspection robots and disaster-response robots are brought to the field for inspection. It is not a competition, but the inspectors, composed of ordering parties (the Ministry of Land, Infrastructure, Transport and Tourism and the like), users, developers (NEDO, the Ministry of Economy, Trade and Industry), researchers of robotics, civil engineering and the like, evaluate robot systems from various viewpoints to help improving the methods for research and development and operation.

Another example is the "Research and Development of Disaster-Response Robots" project of "The International R&D, Demonstration Project in Environment and Medical Device Sector/The International R&D and Demonstration Project on Robots/Research and Development of Disaster-Response Robots (USA)", which has been carried out by NEDO since FY2014. This project develops disaster-response robots, participates in a robot competition hosted by DARPA in USA (Disaster Robotics Challenge), and also plans to carry out demonstrations in Japan.

In the future, while cooperating with the hosting entities of existing robot-related competitions, users and operators of robots, manufacturers, researchers and the like, the consideration will be carried out with Robot Revolution Initiative playing a central role. The executive committee will be started within this year to establish the system, the concrete style and competition items will be determined by 2016, and also a preparatory competition will be held in 2018. And then, the Robot Olympic will be held in 2020.

(3) Goal for 2020

If industry, government, and academia share the common goal of holding the Robot Olympic (provisional name) concurrently with the Tokyo Olympic and Paralympic Games, the research and development of robots will be accelerated in five years to come. At the same time, it may serve as a trigger to actually introduce and diffuse robots into actual daily life and workplaces.

Robots that will participate in this Robot Olympic (provisional name) should be not only those for competition but also those that are actually used in various scenes and workplaces in society or those actually working. And it is important to continue the cycle of innovation such that even after the Tokyo Olympic and Paralympic Games, new robotic technology is continuously tested via these competitions, verified, and accepted in society.

We should aim at a society where visitors to Japan can see robots being utilized in various areas, and should establish the environment such that when new robots are developed, they are demonstrated and introduced in Japan for the first time in the world. That is what is meant by "to become a showcase for robot utilization", which can be a driving force of the robot revolution.

Chapter 2 Particulars by Sector

Section 1 *Manufacturing* Sector

(1) Background

In the manufacturing sector of our country, the introduction of robots has mainly been promoted among major corporations for such uses as welding and painting processes in the automobile industry and parts mounting processes in the electrical and electronic industries. On the other hand, a great deal of the work in the preparatory process (setup process), such as parts supply, has continued to be carried out manually in most operations including large corporations, and especially, medium-scale and smaller companies have been very slow in introducing robots into their operations.

For example, according to the statistic data on the shipment value of major industrial robots by size of consignees[10], the ratios of the shipment value to small- and medium-sized companies of the robots for use in welding; materials management and transport control; picking, lining-up, packaging, and receiving and shipping; and general assembly are 22.4%, 9.5%, 16.2%, and 0.1%, respectively, indicating that the majority of the above shipments is for major companies.

In the Japanese manufacturing industry, active investments have been made for mechanization including the introduction of robots from the1980s and onward, resulting in increase in labor productivity, but it seems that such investments have levelled off in recent years regardless of the size of companies. It is important to study once again how to utilize robots effectively and to try to enhance competitiveness.

(2) Basic concept

It is a big challenge how to introduce robots not only to the major companies that have proceeded with utilization of robots mainly in the automobile and electrical & electronic industries, but also to medium-scale and smaller companies, in considering the future utilization of robots in the manufacturing sector. Also, in view of the fact that certain industry sectors that are slow in adoption of robots including large companies continue to exist, it is necessary to promote the utilization of robots in such sectors. In addition, there remain processes where the utilization of robots is not advanced even in the automobile and electrical & electronic industries. It is therefore necessary to promote the technical development and measures to support these industries which account for a high proportion of the total shipment value.

It is necessary for the areas in which robots are effectively utilized to broaden

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[10] Supply and Demand Trends in Robot Industry, 2014 edition (Japan Robot Association)

multifariously, resulting in an increase in the size of the market for robots so that the use of robots can be promoted among medium-scale and smaller companies and in a variety of manufacturing sites. On the other hand, it is expected that the markets to be created in the new versatile areas will form a long tail market in total with a number of small-scale market segments contained.

In these new markets, customization is required in compliance with a wide variety of users' needs. Consequently, the business model there will be different from those for the conventional industrial robots that have enabled to win high-volume orders through the customization to meet the needs of major users including automobile manufacturers.

It is important that the SIer should bring together the manufacturers that have a variety of technologies and expertise and present proposals concerning the utilization of robots based on the various needs of users and also that such manner of the introduction of robots as leads to the formation of production lines should gain prominent attention to be utilized widely, in order to diffuse the use of robots widely in the industry including medium-scale and smaller companies.

Specifically, it is important to try to improve SIer's own response capacity through business opportunities, such as introduction verification projects, and at same time, to develop a platform for the integration of the robot technologies of various manufacturers by such measures as the wide use of standard modularization of hardware and software and the common base to bring them together so as to develop an environment to facilitate such activities. When the above scheme is realized, the situation will come closer to such a status that everybody can utilize robots easily ("easy to use"), and thus, it can be converted to a business structure in which the cost reduction concerning system integration and the advantage of scale through horizontal expansion play a role. In addition, it is also important to promote the development of element technologies to have the time required for system design and adjustment substantially shortened. It is vitally important to proceed with the improvement of the SIer in productivity and constitution through these efforts for the purpose of diffusing the new ways of utilizing robots.

Furthermore, it is important for medium-scale and smaller companies to become convinced of the improvement in productivity and profitability due to the introduction of robots before robots are widely introduced to them. Also, besides the development of robots, it is necessary to develop inexpensive and simple teaching methods that medium-scale and smaller companies can afford to use and to bring up necessary technicians.

On the other hand, the utilization of robots will remain important even to the major companies which have engaged in the introduction of robots in the light of improvement in productivity, international cost competition, and also measures against labor shortage, and it is necessary to increase the utilization of robots in such segments as have so far made little progress in the utilization of robots including the so-called "three-products industries", consisting of food, cosmetics and pharmaceutical industries.

In addition, it is important to try to pursue the sophistication of production systems themselves utilizing robots, including coordination system among devices and linkage with the order situation by utilizing IT, and to establish consistently optimized production lines and supply chains for the purpose of maintaining and strengthening the competitive edge of the manufacturing industries.

(3) Areas where the utilization of robots should be promoted (priority areas)

There exists in medium-scale and smaller companies the minute, labor- intensive work, such as parts processing and assembly, which is carried out jobs for major companies on a subcontract. Under the current situation, as these kinds of work are not necessarily simple, it has been difficult to substitute labor work with robots, and moreover, the utilization of robots has not been advanced since many medium-scale and smaller companies have no adequate reserve for capital investment. An approach is required in the aspect of policies and technical development that will facilitate the introduction of general-purpose multi-skill robots, etc., superior in cost-effectiveness in response to the needs of work at site and in accordance with the size and production capacity of the companies in question.

Also, in regard to the three-product industries (food, cosmetics and pharmaceutical industries), further progress in the utilization of robots is expected due partly to the recent development in robot technology while they different among others in the areas where room for robotization still remains. As a high level of hygiene is required in common in these areas, the robot is in a sense more suitable than the human operator.

With regard to the food industry, efforts will be focused on the automation of simple food manufacturing processes and the development and introduction of robots that can substitute the workers to perform the labor-intensive work, such as preparation of boxed lunch and delicatessen food which is carried out in the backyard process by a large number of part-time workers employed for the job.

Also, with regard to the cosmetics and pharmaceutical industries, the utilization of robots will be actively promoted for enhanced labor productivity so far as it can be justified in terms of cost-effectiveness and the takt time of working process.

For large corporations, efforts will be pursued for the development of multi-skill robots featured by general versatility and adaptability which are capable of meeting the requirements of the processes such as preparation and setup, where robotization has been difficult in the past. Efforts will be also made to grope for new ways of human-robot interaction to allow human and robots to work in a coordinated manner and also for the reproduction by robots of the expert craftsmanship.

Also, with regard to the sophistication of robots themselves, development and verification will be pursued for the coordination system among devices (robot to robot,

robot to machine tool, robot to parts, etc.) and also the network-type robots. In addition, towards the increase in productivity and improvement in quality of product itself beyond the existing limitation by means of establishment of flexible and consistently optimized production system against a backdrop of IoT, the thorough automation engulfing all the processes to make a whole factory function like a single robot will be pursued through the activities of the Robots Revolution Initiative, and the standardization necessary to link the world's most advanced production systems is to be promoted.

Finally, it is essential to keep the robot as a product competitive internationally, and the competition with the robots from newly industrializing countries will be increasingly intensified in the future. Accordingly, it is critically important to establish a foothold in all aspects of element technologies, mechanisms, materials, control, and information and telecommunication for production machinery. Needless to say, it is necessary to enhance the fundamental technological capability of production machinery as a whole, by adopting aggressively boundary technologies of which employment has conventionally been withheld, relating to the basic structure, control mechanism , etc. of robots and attempting to foster cooperation with various industries, so that new innovation may be brought about.

(4) Targeted ideal situation as of 2020 (KPI)

As the targeted ideal situation as of 2020 (KPI) in the manufacturing sector, it is assumed that as a matter of macro index, while the market scale of robots used in the manufacturing sector in 2020 is to be doubled (from 60 billion yen to 120 billion yen), the rate of growth in labor productivity in the manufacturing industry is to be increased to more than 2% annually as described in the revised version for 2014 of the "Japan Revitalization Strategy".

Also, as a part of the efforts by sector, it is targeted to increase the rate of robotization in the assembly process, which is the key to the achievement of the target in 2020, up to 25% for large-scale companies and up to 10%, which is the current rate in large-scale companies, for small- and medium-sized companies[11].

Some 30 unprecedented cases of the utilization of robots will be annually collected and published as advanced best practice in the next five years in order to disseminate the cases of the utilization of advanced robots throughout Japan. Such cases will include the creation

[11] While the rate of robotization in the automobile assembly process is about 7% as of 2010, the rate of introduction required for the achievement of the target is preliminarily computed by reference to the analysis in the "Industrial Spillover Effect of RT (robot technology) and Market Analysis" (March 2008) by the Economic Research Institute, Japan Society for the Promotion of Machine Industry, and also on the basis of the market potential as of 2020 based on the possible improvement in working efficiency due to the advancement of robot technology and potential reduction in the cost for introduction of robots.

of human-robot interaction lines designed rationally with the utilization of dual-arm multi-skill robots and the formation of production lines based on the utilization of coordination systems among various devices and network robots.

Furthermore, with regard to the SIer that will be the key to ensuring a flexible response to the future needs of users, the SIer market will be expanded in a manner to exceed the increase in the size of the market for robots. In connection with the standard modularized hardware and software and common base, as prerequisite to flexible system design, arrangements will be made to develop more than 1,000 different types of interoperable hardware products equipped with the common robot operating system and to have them brought to the market.

(5) Measures and policies towards target achievement

It is important to make a consistent approach ranging from the development of robots to the verification at site of the authenticity of introduction based on the needs of users, in promoting the utilization of robots in the *manufacturing* area.

With regard to technical development, the priority areas for development will be narrowed down to those described in Item (4) above, and the needs of users concerning the utilization of robots and the way out for commercialization will be clearly defined. Then, the technical development is to be implemented towards the selection of, and concentration on, the functions to be specialized in.

<Related measures and policies>

◇ *The technical development project for commercial application utilizing robots (METI)*

- *Technical development will be implemented for manufacturing and service sectors towards the selection of, and concentration in, the functions to be specialized in, after the needs of users concerning the utilization of robots and the way out for commercialization are clearly defined. Human resources that are capable of developing robot systems in accordance with the needs at the site will be also developed.*

Especially for medium-scale and smaller companies as different from large companies which are advanced in the introduction of robots, it is important to take elaborate measures at each stage including, besides the development of robots, matching between needs and seeds, calculation of the cost-effectiveness of the introduction of robots, and also consultation including management assistance in the introduction of robots, and the verification of the introduction, until the robot market and the system for promotion of the introduction of robots are made ready.

Also, it is important to strengthen the capability of creating robots which are capable of responding flexibly to the diversified needs of users in order to broaden the base for the utilization of robots in the new segments of the three-product industries and medium-scale and smaller companies, etc.

Under the *Project for the Verification of the Effectiveness of the Introduction of Robots*, the move is to be accelerated towards the expansion of the SI market and commercialization of interoperable hardware products by means of making it a scheme with the SIer that serves as the key to the introduction of robots in the years to come, and also adopting aggressively the interoperable robots equipped with the common robot operating system.

<Related measures and policies＞

◇ *Project for the Verification of the Effectiveness of the Introduction of Robots (METI)*

- *Verification of the effect of the introduction of robots is to be implemented in such segments of the manufacturing and service sectors as robots are not utilized yet, for increase in productivity. At the same time, feasibility study (FS survey) will be implemented concerning the introduction of robots to promote the introduction of robots by demonstrating its cost-effectiveness. Also, in the above-mentioned verification procedures and feasibility study, the service providers (system integrators) are to be utilized and raised as instrument capable of supporting the utilization of robots and system architecture.*

◇ *Establishment of "Robots Revolution Initiative"*

- *An industry-government-academia forum, which has functions to "promote matching between needs and seeds, and to create solutions" is to be set up in 2015, so that such robots as are capable of responding efficiently to the needs from versatile areas may be created.*

It is necessary to advance efforts for improvement of the environment in terms of regulations, reformation, etc. as well to have robots utilized effectively for promotion of the utilization of robots.

A recent specific effort is the clarification of the safety standards on cooperation work between men and industrial robots. With respect to the industrial robots capable of performing collaboration work with men, it is international practice to allow such robots to work together with men regardless of their output values, so far as certain measures to secure safety are taken. Meanwhile, in Japan, it was necessary in principle to fence in an industrial robot whose maximum output is greater than 80W. Then, the safety standards were defined to enable the human-robot cooperation in December 2013 on the basis of the "Regulatory Reform Implementation Plan" (adopted at a Cabinet meeting in June 2013). Accordingly, the collaboration work between humans and robots whose maximum output exceeds 80W without fence around it so far as certain conditions are met.

<Related measures and policies>

◇ *Review of regulations*

- *With respect to such cooperation work between human and a robot, whose rated output exceeds 80W, as approved by the international standards, the "Partial Amendment of the Notification of Enforcement under Article 150 (4) of the Industrial Safety and Health Law concerning Industrial Robots" was notified in December 2013. Thus, the safety standards to enable such human-robot cooperation were clearly defined.*

With respect to the robots which are fast in technical progress and of which field of utilization is expanding into new spheres, it is important to proceed with necessary regulatory and system reform perpetually while paying adequate attention to safety, in order to accelerate further introduction of robots.

Section 2 Service fields

(1) Background

The ratio GDP and the number of employees in the service industry of Japan to all the industries are as high as about 70%. By comparison of labor productivity, however, Japan's labor productivity is about 60% of that of the United States, which is lower than other countries. In light of the anticipated decline in birth rate and surge in the number of the aged, raising labor productivity in the service industry is an urgent problem Japan is facing.

Japan's service industry has wide room to automation as it still relies on manpower unlike the manufacturing industry that has improved labor productivity by using robots over a long period of time.

From these viewpoints, labor productivity in the service industry will be improved and values added will be increased through innovation by encouraging use of robots in the service industry, so that human beings can concentrate on high value-added work, rather than work focusing on manual labor and that, for example, high-quality hospitality can be provided.

(2) Basic concept

When considering use of robots in the service field, it is important to analyze work and measure effect by using specific numbers and data, have a clear picture of work that should be done by human beings, work that should be done by robots, and work that should be done by men and robots in cooperation, and strategically narrow down on important fields related to robots, while taking into account the situations and vision of the future at the sites where robots are used in the same manner as in the other fields, as the service industry covers a wide sphere.

Because robots have rarely been used in the service industry, however, the actual situation is that the user has little expertise in making the use of robots and, conversely, the manufacturer has difficulties in finding the needs for robots. To propel use of robots in the service industry, therefore, it is important to develop players who will act as a go-between for users and manufacturers and create a venue for matching demand for and supply of robots.

At the site of service, there is high expectation for use of robots from a viewpoint of respecting the humanity of workers as such a site is important for pursuing the value that can be provided only by men in order to increase the value added of a service by improving the satisfaction of the customer.

(3) Fields where use of robots should be pushed forward (important fields)

Many service industries are labor-intensive. Above all, businesses such as wholesale, retail, hotels, and restaurants are considered to potentially have a lot of needs for use of robots because these businesses involve monotonous work to some extent and are suffering from a labor shortage.

Generally, the service industry is divided into processes based on human beings and those based on objects.

Many service businesses spare not much time for the human-related processes (i.e., services in guest rooms or at tables). According to an analysis, waiting staff, who are supposed to spend a lot of time for the human-based processes actually spend 11.7 to 21.4% of their time at certain inns.

In contrast, some pioneering cases of the backyard object-based processes where automation has been moved forward by introducing robots can be found, such as a "meal-serving wagon transportations system" (Kagaya), "pharmaceuticals distribution center advancement robot system" (Toho Pharmaceutical Co., Ltd., NEC Corporation, Daifuku Co., Ltd., Yasukawa Electric Corporation) that won the first prize in the "robot business/social implementation section" of the 2014 robot award.

According to a business hearing conducted by the Ministry of Economy, Trade and Industry of Japan, the dominant opinion is that a top priority should be given to automation of the object-based process regarding use of robots in the service industry. In the future, evolving the field of service by promoting use of robots for the object-based processes, which is the backyard of hotel and restaurant businesses, and pushing automation forward, so that human beings can concentrate their effort on processes for creating high values added is considered to be one direction.[12]

In the meantime, it is necessary to bring into perspective a study toward automating human-based processes, such as development of the next-generation element technologies for the time being as a medium-term strategy to cope with labor shortage, while promoting the object-based process, which is mainly in the backyard. It is also needed to use and automate robots that can reduce the load of office work by men by such means as recording through voice recognition, so that men can provide services of the higher quality.

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[12] From the viewpoint of the competitiveness of the robot industry that underpins introduction and spread of robots, robots that perform work that is simple for both human beings and robots, such as transportation, can be produced on a commercial basis within a short time. By focusing on processes which are simple for men but difficult for robots to realize, high values added can be achieved over a long time.

For the future research and development and market expansion, it is essential to create new services, which could not be found in the past, by promoting joint researches with various fields. Bringing into perspective the fields where a robot itself can be the source of a value, including, for example, the fields of education service (foreign language teaching robots), communication, content, and entertainment, it is also important to understand the needs in these fields, develop required technologies, and create necessary environments.

(4) Objectives that should be achieved by 2020 (KPI)

As the objective (or key performance indicator (KPI)) the service field should achieve by 2020, Revision 2014 of "Japan Reconstruction Strategy" cites a macro index of a 20-fold increase of the market scale of robots used in the non-manufacturing sector on which robot services will concentrate in 2020 from 60 billion yen to 1.2 trillion yen and a three-fold growth rate of labor productivity in the service field from the average of 2012 to 2013 of 0.8% to 2.0%.

In addition, use of robots for object-based processes in the backyard should be thoroughly bolstered in each sector, so that, as said above, people can concentrate on human-based processes.

Specifically, efforts should be made in the logistics field so that operations and delivery management at the contact points between transportation and a site, such as for locations of arrival and delivery of goods (where cargos are loaded to or unloaded from trucks from/to warehouses) can be consistently automated by using robots. Even if automating is difficult (for example, in a process where objects in unspecific shape or flexible must be picked up and placed), use of robots in the field of logistics should be thoroughly pushed forward by, for example, decreasing the weight and improving the performance of assist suits to mitigate the workload at the worksite by using such assist suits.

At present, the rate of use of robots for picking, screening, and checking operations, which hold a key to successful spread of robots, is almost zero. In the latest example of the above mentioned "pharmaceuticals distribution center advancement robot system", it is said that the potential of introducing robots is 80% to 90%. Taking into account this potential and rate of use of robots which is needed to achieve market expansion by 2020, an increase of about 30% in use of robots for picking, screening, and checking operations should be aimed.[13]

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[13] This rate of use of robots needed to achieve the target of market expansion by 2020 was calculated by using the situation of using robots at current advanced distribution centers and considering the potential of introducing robots by developing individual robot technologies and advancing the whole distribution system.

For wholesale and retail businesses, hotels, and restaurants, which are considered the promising fields of the service industry, automation by using robots should be promoted to facilitate simple but heavy-load backyard operations like collecting and placing tables and cleaning.

To this end, examples of the best practice related to use of robots in the service field will be collected and disseminated nationwide to create a virtuous cycle of solving labor shortage in the service industry, improving productivity, and increasing wages. To collect good examples of best practice, the result of “Robot Introduction Demonstration Project” to be described later, as well as the examples introduced at “Robot Revolution Realization Conference”, will be used. A collection of about 100 example cases gathered in this way will be published in 2015.

(5) Measures toward achieving goal

To embolden use of robots in the service sector, proceeding with consistent measures, from development of robots that meet the users’ needs to demonstration of introduction of them to the actual work place, is as important as in the manufacturing sector. In the service industry that covers a vast range, it is vital to carefully select fields to which a priority should be given in developing robots, clarify the users’ needs for use of robots and outlets for marketing them, and develop technologies toward selection and concentration of functions for specialization.

<Related measures>

◇ *Project for development of technologies applicable to creating markets using robots (Ministry of Economy, Trade and Industry) [See above.]*

The service field has few records of having used robots in the past and lacks the cost effectiveness of using robots and expertise in using robots. Therefore, making clear the cost effectiveness of introducing robots and lowering the cost of introduction through a feasibility study (FS) and an introduction demonstration project is considered extremely effective for expanding introduction of robots.

<Related measures>

◇ *Robot introduction demonstration project (Ministry of Economy, Trade and Industry) [See above.]*

As mentioned above, the service industry, which has few records of having used robots, runs short of expertise in using robots, and there are many cases where users do not clearly understand in what process the robots can be used. To turn around such a situation, the role of system integrators (SIer) that intermediate between the user and the manufacturer is as important as in the manufacturing industry. Conducting initial consultation on introduction of robots is believed especially important for the service field. “Robot Introduction Demonstration Project” is intended to expand the SIer market at a growth rate higher than that of the robot market by creating a scheme that gets SIer involved.

<Related measures>

◇ *Establishing “Robot Revolution Initiative Council” [See above.]*

Creating an environment for effectively using robots in the field of service is important. One of the points at issue is, for example, unification and standardization of containers and pallets used in the field of logistics.

In the logistics field, unification of containers and pallets (arrival pallets, arrival containers, delivery boxes, delivery pallets) is essential toward materialization of measures to enhance the overall efficiency through complete automation and 24-hour automatic delivery to warehouses (which are directly connected with production lines). The size of some pallets has been standardized (1,100 mm x 1,100 mm) in compliance with Japan’s domestic standard, JIS, and international standard ISO. In the future, steps to spread standardized pallets should be taken. In EU, for example, the standard of pallets is unified and palletizing/de-palletizing operation has been automated at contact points between the logistics operation and work place. Taking these situations into consideration, necessary actions should be taken.

Section 3 Nursing and medical fields

(1) Background

It is expected that the number of the aged 65 years or older reaches about 7.09 million over 15 years from 2010 to 2025 and that population aging rate of the entire society (ratio of the aged to the total population) substantially surges from 23% to 30%, giving rise to an increase in needs of medical care and nursing.

In addition, the baby boom generation reached 65 years or older in 2012 to 2014 – an increase of more than one million of the aged per annum. Consequently, the necessary number of care workers is said to rise from 1.7 million of 2012 to about 2.5 million in 2025. However, it is reported that 70% of nursing care workers who are currently working are suffering from a backache, calling for mitigation of the workload at care-giving sites.

In the medical field, minimally invasive and precise-motion surgical robots and similar medical devices have been developed in recent years and employed at many medical institutions.

(2) Basic concept

The basic policy is to help people continue their self-sustaining lives in a region they are familiar with even when they have reached the age at which they need nursing and medical care.

Specifically, work environments where nursing workers can provide services with satisfaction will be created by making the best use of robotic nursing equipment while maintaining the basic concept that care is given by human hands, and a paradigm shift to enhancing the work efficiency and reducing the number of workers will be aided by use of robotic nursing equipment at care sites. In the scene of development, specific needs at care sites will be identified so that highly practical equipment that can meet the needs at sites will be developed, research and development of such equipment will be supported, and matching of care sites and development sites will be aided.

In addition, through accumulation of health and life data and communication with old people, measures to promote introduction of robots with sensor technologies and artificial intelligence will be pushed forward with an eye on looking after the aged and preventing them from falling prey to a serious disease such as dementia.

To mitigate the workload of health care workers, efforts will be made to produce robotic wheelchairs that, making the best use of sensor and network technologies, allow the aged to move around indoors and outdoors independently and safely.

For the purpose of providing innovative medical device using robot technologies to medical sites quickly, various supports will be extended at the research and development stage of the device. Technical evaluation indexes, etc., utilized at the time of review of novel medical device that is needed at many medical sites and is very feasible will be formulated and publicized in advance in order to enhance the efficiency of product development and shorten the time required for approval review.

(3) Fields where use of robots should be pushed (important fields)

A survey conducted in 2011 by the Ministry of Health, Labor and Welfare with 220 nursing facility managers and care workers, “Project for Helping Putting Welfare Equipment and Nursing Robots into Practice”, found that needs of helping the aged transfer or move, excrete, and take a bath, and live their everyday lives, and supporting the old with dementia were high in the field of supporting nursing homes. In response, the Welfare of Health, Labor and Ministry and the Ministry of Economy, Trade, and Industry will decide on important fields of these types of care where problems of using robotic nursing equipment should be solved by using robot technologies, and move forward toward solving those problems.

* “Important development field” (mainly in nursing field) Transfer support (wearing type), transfer support (non-wearing type), transfer support (outdoors), transfer support (indoors), excretion support, watching over those who have dementia (for institution), watching over those who have dementia (for home), bathing support

In the medical field, spread of minimal invasive, precise-motion surgical robots and similar medical devices that are expected to alleviate the burdens of patients will be propelled.

(4) Objectives that should be achieved by 2020 (KPI)

Creating safe and stable work environments will be pushed forward by using robots that aid the aged to lead self-sustaining life by helping them move around when they go out so that they can live in a region to which they are accustomed even though they need care, and by introducing to medical sites the nursing robots that mitigate the physical burdens of care workers by making it easy for those who they look after to transfer. In addition, use of such robots for preventing people from needing care, rehabilitation, and health promotion will be propelled. Moreover, encouraging introduction of the robots that are applicable to medical institutions will also be considered.

Regarding development and promotion of use of nursing robots, a study of items covered by the nursing-care insurance system will flexibly be promoted in order to keep abreast with technological innovation of nursing robots and smoothly alleviate the workload of home health care. In addition, supply of high-quality services that can be achieved only by human beings will be promoted while enhancing the efficiency of nursing work and lowering the number of health workers needed, by using nursing robots.

Development of medical device, including surgical robots, will be propelled so that such device will spread among medical institutions. AtAt the same time, the pre-market approval review of brand-new medical device, including that utilizing robot technology will be smoothly conducted. The targets of standard total review period from the receipt of application of brand-new medical device to its approval are to become 14 and 10 months for normal review item and priority review item, respectively.

As a result, the following goals will be achieved:

- The domestic market scale of surgical robots will be expanded to 50 billion yen by 2020 as sales target.[14]
- Awareness of nursing methods using the newest robot technology will be changed to increase the percentage of people who wish to use nursing robots for providing care to 80% from the current 59.8% and of those who wish to have robots used when undergoing care to 80% from the current 65.1%.
- The risk of care givers of suffering a backache will be lowered to zero by using nursing robots for helping the aged transfer.
- More than 100 cases of support to put medical care-related equipment using robot technology will be implemented in 5 years from 2015 to 2020.

(5) Measures toward achieving goal

Related ministries and agencies will cooperate in implementing projects for developing, putting into practical use, and spreading robotic nursing equipment. Specifically, measures will be taken mainly in the following important fields designated by the Ministry of Health, Labor and Welfare and Ministry of Economy, Trade and Industry in order to proceed with development of robotic nursing equipment that is clearly needed at the work site but has a problem of lowering the price, by narrowing down on functions.

In addition, creation of environments and extending support toward promotion of introduction of robotic nursing equipment that is already at the commercialization stage will be carried out to drastically propel spread and use of such equipment at work sites.

(Fields on which a focus is placed in developing robotic nursing equipment in the future)

- Transfer aids

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[14] Potential market of 2020 scale calculated based on possibilities of future expansion of nursing demand at the nursing site, improvement of work efficiency thanks to progress in robot technology, and cost reduction resulting from introduction of robots.

Wearable equipment that assists care workers by using robot technology

⇒ Alleviates the physical workload of the care workers in the scene of transfer.

- Mobility aids

  Walking support equipment using robot technology which can help the aged go out and safely transport baggage, etc.

  Walking support equipment that helps the aged move around, stand up, and sit down indoors, go to and return from the restroom, and help maintain posture in restroom

  ⇒ Draws the ability of the aged to the maximum extent to allow them go out for shopping alone.

- Toilet aids

  Installation position adjustable restroom that uses robot technology for excretion

  ⇒ Allows the aged who have difficulty to move to restroom to live comfortable, self-sustaining lives by using toilet placed at their bedside.

- Monitoring systems

  Platform of equipment that is used at nursing facilities and that uses robot technology, equipped with sensor and external communications functions

  Platform of equipment that is used for home health care and that uses robot technology, equipped with sensor and external communications functions

  ⇒ Allows even dementia patients to be watched over and lead self-sustaining lives at their beloved homes

- Bath aids

  Equipment that supports a series of operations to get in and out of bathroom by using robot technology

  ⇒ Lightens the workload of a nursing worker by using equipment when the worker helps an old person get in and out of bathroom

◇ Project for Helping Putting Welfare Equipment and Nursing Robots into Practice (Ministry of Health, Labor and Welfare)

- Creating an environment that prompts practical use of nursing robots will be promoted by conveying the needs at care sites and conducting demonstration experiments of prototype equipment at the early stage of development of such equipment.

(Specific measures)

- Conducting monitor investigation

Support toward putting highly feasible robotic nursing equipment into practical use by taking opinions at care sites into the development cycle at the early stage of development

Providing detailed support to development companies through exchange of opinions with care givers, seeking advices from experts, and conducting a monitor investigation at care sites in accordance with the situation of development of prototype equipment starting from the stage of conceiving idea

- Creating venues for monitor investigation

  Listing facilities and offices that can cooperate in a monitor investigation and conducting appropriate matching in accordance with the characteristics of equipment still in an experimental production stage

- Dissemination and enlightenment activities
- Promoting enlightenment activities so that every citizen can gain necessary knowledge and information on robotic nursing equipment

  Promoting spread of nursing techniques using robotic nursing equipment

- Providing consulting service

  Establishing consultation windows that respond to requests from care sites and development sites for consultation over use of nursing robots

In the future, cooperation with the important fields for this project will be moved forward by providing as much assistance as possible to putting into practical use the robotic nursing equipment that will be designated as an important field and will be developed, by using the framework of projects to support putting into practical use of welfare equipment and nursing robots.

The PDCA (plan, do, check, and act) cycle of this project will be reinforced, the results of monitor investigations will be periodically checked and evaluated, and the effect how far the nursing robots spread on the market will be measured. In addition, the project will be implemented to disseminate the expertise and process involved in development of effective robotic nursing equipment by providing easy-to-understand information on good examples to the citizen.

To seek understanding of the effectiveness of introducing robotic nursing equipment to care sites from every walk of life, holding symposiums intended for care service businesses and health care workers and compiling manuals concerning use of robotic nursing equipment at care sites will be considered.

◇ Nursing-care insurance system (Ministry of Health, Labor and Welfare) <See above.>

As needs for nursing equipment using robot technology has been increasing, it is necessary to accelerate the spread of such equipment by providing appropriate support to developer and nursing workers.

Therefore, systems for accepting and reviewing requests for the items of nursing-care insurance system, which are at present reviewed once every 3 years, will be made flexible, so as to be able to quickly respond to technological innovation. Specifically, requests for payment of nursing insurance will be accepted as necessary, those of the present items that can be interpreted will be quickly disseminated, and addition of new items will be decided as necessary by holding "nursing insurance welfare tool evaluation and review committee" and "nursing care payment subcommittee of social security deliberation council" meetings as necessary.

◇ Local medical and nursing security fund (Ministry of Health, Labor and Welfare)

- Supports introduction of nursing robots that contribute to mitigation of burdens and enhancement of efficiency of nursing work performed by nursing workers through trailblazing measures to create work environments easy for nursing workers to work such as nursing facilities

◇ Robotic nursing equipment introduction promotion project (Ministry of Economy, Trade and Industry)

- Researches and develops low-price robotic nursing equipment that can actually be "used". At the same time, lays downs safety, performance, and ethical standards and creates environments necessary for introducing such equipment.

So far many expensive, advanced robots, such as humanoid robots, have been developed. For example, development of a humanoid that can hold up in its arms a person requiring by detecting the person with high-accuracy sensors and can work almost in the same manner as human nursing worker may be a possibility. Nevertheless, it can be easily anticipated that such a humanoid cannot be purchased by and spread to nursing sites with poor financial power. Therefore, development of robots that can fill the gap between the manufacturer and nursing site, has only functions and parts absolutely necessary, eliminating unnecessary functions and parts, as a package, and can be "used" at nursing sites is a policy issue.

For this reason, the Ministry of Health, Labor and Welfare and Ministry of Economy, Trade and Industry have decided on important fields where problems should be solved by using robot technology and started development of inexpensive robotic nursing equipment that can be "used" at nursing sites, and will continue to provide development support toward putting such robots on the market as soon as possible. In doing so, competitions for development by stage gate method will be encouraged and a time limit will be set for development so that the robot can be introduced in the market early. Specifically, introducing in the market the robots intended for two fields, "for transfer support (indoors)" and "for watching over dementia patients (for institutions)", starting from 2015 will be aimed, and equipment targeted at the other fields will be put on the market one by one as soon as its development has been completed.

To introduce robotic nursing equipment in earnest, formulating standards including those on safety will be extremely important. Creating an environment aimed at introducing robotic nursing equipment has already been started by establishing safety standards of robotic nursing equipment, ethical standards concerning demonstration of such equipment, and performance standards that evaluate that the equipment can be "used". Other standards necessary for each of the important fields will be prepared by 2017.

Regarding safety standards, an international safety standard ISO13482 of daily life supporting robots, including robotic nursing equipment, went into effect in February 2014 on the initiative of Japan, and Japanese robotic nursing equipment won third-party certification based on this standard. In the future, development of robots conforming to international standards like this will be supported and safety standards peculiar to robotic nursing equipment will be reviewed ahead of the world while using the framework of regulatory cooperation mentioned above.

It is also indispensable to understand movements peculiar to each country such as the needs at nursing sites in order to export the results of development. For this reason, cooperation with other countries in laying down rules on robots, including those for demonstrating and ensuring safety of robots overseas, will be reinforced.

◇ Project for advancing ICT applications in medicine, caring and health care for next generation (Ministry of Internal Affairs and CommunicationsCommunications)

- Verifies possibility of using robots to watch over and prevent dementia patients from advancing in severity by gathering the health and life data of the aged by using sensor technology and by communicating with them through artificial intelligence.

◇ Project for promoting development of equipment supporting independence of disabled people (Ministry of Health, Labor and Welfare)

- Supports development of equipment (products that can be put into a practical use) for supporting independence of the disabled (including development of software), as well as development of robotic nursing equipment, as the market for such independence supporting equipment is small and it is difficult to establish a business model.

◇ All-Japan projects for development of medical equipment (Health & Medical Strategy Office of Cabinet Secretariat, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Health, Labor and Welfare, and Ministry of Economy, Trade and Industry)

- Promotes development of medical equipment, including that which uses robot technology, and human resources in cooperation with the Health and Medical Strategy Office of the Cabinet Secretariat, the Ministry of Education, Culture, Sports, Science and Technology, the Ministry of Health, Labor and Welfare, and the Ministry of Economy, Trade and Industry in providing support through a Network for Supporting the Development of Medical Devices in an all-Japan framework.

(Examples of medical equipment expected to be developed)

- Robots that can make possible minimally invasive surgical operations (which leave only a small scar and lowers bleeding and pain after the operation) that mitigate the burden to the patient by using techniques such as to replicate the movements of the joint of an arm (such as operating a forceps at various angles or many forceps at the same time), which is considered impossible with the surgical techniques of human doctors, and simultaneously obtain various visions
- Robots that estimate the effect of medical treatment suitable for a patient and a complication by gathering medical information (through such things as images and biomonitoring) to enhance the safety of the treatment
- Robotic machines that can cure the diseased part that is impossible to cure by using dexterous techniques Japan is proud of (such as robot capsule endoscopic surgery)

◇ Creation of technology evaluation indexes concerning novel medical device(Ministry of Health, Labor and Welfare)

- Prepares technology evaluation indexes utilized at the time of review of novelnovel medical device in orderorder to quickly provide innovative medical device, including that utilizing robot technology, to medical sites.

Section 4 Infrastructure, disaster response, and construction fields

(1) Background

The present issues in the fields of general construction, infrastructure maintenance and management, and disaster response are as follows:

1) General construction field

As the population and birthrate decrease and the number of the aged increases, the number of young workers seeking job in the construction industry is falling and people leaving the industry is rising. It is therefore a pressing issue to secure and develop construction workers who can work over a medium term.

In particular, there is a growing concern that the engineers and skillful workers who have played the central role of the construction production system will run short and thus steps to ensure the quality of public works in the future are required.

Since the construction industry constructs structures in the natural world, its production system is directly coupled with climate and geology and has features such as outdoor production and production in response to a single order. As compared with the other industries, therefore, the construction production system has an aspect that raising labor productivity is more difficult because an original idea suitable to a given situation, which has to rely on human workers, is always required. This is the reason that the construction production system is demanded to save power, enhance efficiency, and become sophisticated, as well as to develop and secure mid-term workers.

The construction industry has more industrial accidents than the other industries because, due to the on-site characteristics of the construction industry, outdoor work and work at high places are likely involved. Because the construction industry accounts for about 30% of accidents resulting in death in all industries, improving safety at work site is an issue that always calls for workers' attention.

In the meantime, as securing and developing workers in the construction industry is an urgent problem, improvement of the work environments and sites by getting rid of painful and dangerous work as much as possible is expected so that women and young people feel easy to land a job in this industry.

2) Infrastructure field (maintenance and management)

As social infrastructure that was intensively created in the rapid economic growth period starting from around 1955 has been aging at an accelerating tempo, an increase in work and expenses needed to maintain, management, and update it is anticipated.

In addition, energy conservation has increasingly been demanded as it is feared that a shortage of engineers necessary for inspecting, diagnosing, repairing, and updating Japan’s overall infrastructure, including industrial infrastructure, will run short.

3) Disaster response field

The land of Japan is situated in an area of the world where earthquakes and volcanic eruption are highly likely to break out. Of the earthquakes registering a magnitude 6 or above, 20% occurs in Japan. About 7% of the active volcanoes of the world is located in Japan.

In terms of climate, rainy season and typhoons attack the archipelago every year and storm and flood damage takes place every day due to her steep geographical features.

In recent years, Japan has seen many disasters that claimed a heavy toll – eruption of Mt. Ontake and Mt. Asama, and landslide disasters brought by typhoons and a seasonal rain front last year, as well as the Great East Japan Earthquake.

In the situation like this, contribution to accelerating the speed of investigation and response immediately after a disaster struck, decreasing the secondary disaster, making a quick recovery and reconstruction is expected.

Ensuring safety is required even during emergency recovery operation in the wake of a disaster because the risk of secondary disaster is high.

(2) Basic concept

To develop robot technology that is useful at actual, specific site, use scenes of the robot technology should be defined based on the specific needs from the society, and development and introduction should be carried out step by step.

To this end, it is important to grasp the entire process, including pre-process and post-process, as well as partial operations that use robots, and to streamline the entire process.

Development and use of industrial robot technology involves many technological and social aspects. This is why it is important for industries, academic circles, and the government to share short- and long-term targets and cooperate in working out issues.

To do so, it is important to make the target (development target) and market (market scale after development) clear and assume who will own industrial robots developed.

In sharing a target among industries, academic circles, and the government and solving issues in cooperation among them, taking and continuing necessary steps seamlessly and consistently is important by having a bird’s-eye view of deciding on development targets, development assistance, demonstration and trial of technologies at actual work site, and support to accelerate the spread of the technologies.

(3) Fields where use of robots should be pushed (important fields)

Taking into account the above background and basic concept in the fields of general construction, maintenance and management of infrastructure, and disaster response, the fields where a priority should be given to use of robots are as follows:

1) General construction field

The mid- and long-term shortage of workers that is a concern in the construction industry will be solved by introducing robots to save energy, automate work, and help inexperienced, young workers raise their skills to the level comparable to experience workers, as well as by improving the working conditions for skilled workers and encouraging providing young workers with opportunities to play an active part.

Labor productivity will be improved through automation and productivity enhancement by using assistance work.

To improve the work site and environment by eliminating heavy labor and dangerous operations, manual labor at a site with a high risk of human casualty will be decreased by mitigating hard labor at site.

2) Infrastructure field (maintenance and management)

Response to severe fiscal conditions and shortage of engineers for inspection, diagnosis, and repair, which will be a concern in the future, will be coped with by enhancing the efficiency of and advancing maintenance and management by developing engineers through training and introducing robot technologies for maintenance and management.

3) Disaster response field

Time required for investigation and emergency response immediately after a disaster will be shortened by introducing disaster investigation robots to estimate the damage, speed up the response, improve the efficiency of unmanned operations, and ensure a high safety level.

(4) Targeted ideal situation as of 2020 (KPI)

Below shown is the targeted ideal situation as of 2020 in the fields of construction as a whole, maintenance of infrastructure and disaster response.

1) Construction as a whole

The whole construction process including the robot technology will be improved by means of the bold introduction to the construction site of the robot technology including computer-aided construction technology in order to promote increase in productivity and labor-saving with the whole process including the pre-process and post-process viewed as a system. Also, such construction industry as female, elderly and young workers find easy to work by introducing the robot technology to be engaged in dangerous work and heavy labor at site.

As a result, the rate of adoption of computer-aided construction technology which contributes to increase in productivity and labor-saving is to be brought up to 30%. In doing so, the progress management will be conducted with the rate of adoption being clarified for each subject technology so far as possible.

2) Infrastructure (maintenance)

The support activities with robots will be promoted to respond to the sharply increasing demand for maintenance.

As a result, the inspection and repair for 20% of the domestic important infrastructure and dilapidated infrastructure will be made highly efficient by up to 2020 by use of sensors, robots and non-destructive testing technology and some other means.

3) Disaster response

In order to carry out disaster response such as a survey of the disaster site to which it is difficult to get access and emergency rehabilitation quickly and accurately, survey robots will be introduced for the job which requires quick investigation of the status of fall of earth and also remotely-controlled and autonomous robots will be introduced for such work as emergency rehabilitation at the site to which access is not easy.

Furthermore, it is necessary to set up on a regular basis the usage environment for remotely-controlled robot to enhance the effectiveness of the utilization of these disaster response robots.

As a result, such construction efficiency as is comparable to manned operations will be realized even at such harsh disaster sites as the fall of earth and volcanoes.

(5) Measures to Achieve Goals

In an effort to achieve the goals, comprehensive measures will be taken in each phase: (i) supporting technological development, (ii) Encouraging introduction of robots into worksite, and (iii) improving market environment.

1) Supporting technological development

In areas in which robots should be developed and introduced with priority, the development and introduction shall be promoted by appropriating part of cost in the development of technology that meets immediate worksite needs, expanding the measure step by step in view of such on-site needs and robot-makers' technology "seeds".

In infrastructure inspection, such measures are aimed at raising the quality of inspection, efficiency and sophistication by achieving technology that has so far been impossible, such as detecting changes that humans have been incapable to find, and accumulating data of deterioration over time.

As for improvement of labor-saving production process, technological development will be supported in integration with the construction project itself. and the achievement will be shared widely outside the particular order-supply circle.

Technological development to streamline the entire system is also necessary. Along with the development of each robot-making technology, information basis and user interface that process real-time and comprehensive data based on three-dimensional positioning information shall be developed under appropriate division of work among industry, academia and government, thus streamlining the entire system of construction projects. Specifically, 3D topographic data is to be furnished in greater detail, while 3D construction blueprint will be made for more efficient inspection.

In order to help nurturing venture businesses and other firms eager to undertake such projects, it is necessary to introduce practical-application development schemes, assistance will be given to the technological development executed in tie-up between the user and the developer.

In an effort to implement the above,

- create a framework to assist technological development efficiently, and
- upgrade and strengthen subsidization of research & development projects in order to support developers of technology.

2) Encouraging introduction of robots into worksite

Supporting introduction of robots into worksite requires testing and evaluation on actual worksite, as well as feedback to the technology developers. For this purpose, the Ministry of Land, Infrastructure and Industry will support on-site appraisal through its Regional Development Bureaus as need, while promoting its on-site appraisal project for next-generation robots for public infrastructure.

Furthermore, introduction of robots will be encouraged by implementing model projects (trial construction) in which the government itself takes initiative in the use of robots. The ministry will lay out dissemination targets for newly developed technology of superb practicality, as well as adopting the technology in ministry-undertaken model construction projects, such as Model Projects.

At the same time, appropriate assistance to selected users (such as small and medium-sized construction companies) will be given. While assisting small and medium-sized construction businesses in their efforts to invest in the improvement of productivity by using robotic technology, the assistance is also extended to the investment in robotic technology by consultation companies, etc. that undertake inspection and diagnosis

Special-purpose robots, etc. that are difficult to own for private sector, well-planned deployment and secured operation by public organizations are needed. By so doing, the ministry encourages private investment in technological development and production of robots.

3) Improving market environment

It is important to promote standardization in order to furnish good market environment. To be speeded is to standardize information format among different manufacturers, work processes, order-givers and suppliers, while also standardize precast products to be used by construction work using robots.

As for reviewing various legal systems, what is needed is to lay out an environment in which construction robots working in disaster areas and infrastructure-maintenance robots can communicate without difficulty. Further, robot technology will be utilized to improve productivity and to save labor in public works, securing the streamlining of the entire system including supervision and inspection, while always assuring quality of works. For robots of high practicality, their effective and efficient use is to be determined, based on the result of on-site inspection related to infrastructure maintenance and disaster salvation work.

Moreover, in an effort to ensure certification of performance and safety, safety standards, etc. of power-assist technology at worksite, where heavy and laborious work is expected, is to be improved, while at the same time helping the private sector to set up a robot-operation certification system with the backing of the Ministry of Land, Infrastructure, and Transport, as an effort to nurture workers skilled in robot operation.

Through such robot-related projects, it is hoped that the construction industry will be freed from the image of hard and dangerous work, and that, together with its continuous technological innovation, the industry will become more attractive workplace for women and young people.

Section 5　Agriculture, Forestry, Fishery, and Food Industry

(1) Backgournd

In Japan’s agriculture, forestry and fishery industry, the numbers workers engaged in this industry have either declined or have aged. There is a serious problem with not only the number of workers willing to engage in such labor, but the labor conditions on steep slopes under a hot blazing sun are harsh and unforgiving. Similarly, in the food industry, manual labor such as preparing by hand each lunch box individually suggests that labor shortages in this area are bound to become a serious problem.

As for Japan’s agriculture, Japan is faced with fierce completion from low cost produce from abroad and has been forced to either reduce costs or to find a way to add value to their products.

It is against this backdrop that we have turned to robot technology and ICTs as solutions to significantly increase productivity and to create an environment where the aged, the young, women, and a diverse combination of personnel can work in concert with robots

Under this scenario, according to estimates by MITI and NEDO[15][16], the potential market size is estimated in 2020 at approximately JPY 120 billion (approx. 1 billion in JPY 2012) for agriculture and forestry and approximately JPY 100 (approx. JPY 2 billion in 2012) for the food industry.

(2) Our fundamental perspective

In the area of agriculture, forestry, fishery and the food industry, we should put our efforts into significantly improving productivity by actively employing robot technology to mechanize and automate labor to supplement any labor shortages and to employ sensing technology to conserve energy and improve the quality of production.

Furthermore, since much of the labor is conducted under harsh conditions such as on steep slopes under a blazing hot sun, we should put our efforts alieving such conditions which remain reliant of manual labor and by utilizing robot technology as an integral part of ICT, it should be possible to employ unexperienced workers in areas which require high sophistication. In this way, even the aged will be able to continue to engage in agriculture or youths, women and people from all walks of life will be encouraged to take up agriculture, forestry or fishery as their choice of profession.

For example, weeding robots, something in demand in farming villages throughout Japan, we should lay the groundwork to encourage manufacturers, including medium to

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[15] “Market Trends in the Robot Industry” (July, 2013, Ministry of Economy, Trade and Industry), “Market Projections of the robot Industry in 2035” (April, 2010, NEDO)

small local enterprises, to actively enter the market by assessing the needs of the farmers, to estimate the market size for robots, and to understand precisely the technology that is required. It is also important that we proceed with the development of robots by resolving problems manifested in the field with new ideas borrowed from disciplines outside the field of robotics. We should priorities our objectives in resolving the issues we confront in agriculture, forestry, fishery, and the food industry and attempt to bridge the day-to-day needs with the seeds of development in the robotic industry and at the universities. We need to expediently put the robots that have been developed into actual use on the ground to test and confirm how effective they can be. This should hopefully lead to quick commercialization and production in large numbers.

In addition, from the perspective of creating an environment where people and robots share their work together, we should establish measures to ensure safety as well as prepare and optimize a world where robots will be used as part of a system. In such a case, for example, fixtures and containers used for logistics will need to be standardized. Furthermore, we should take advantage of the manufacturing existing at regional medium to small enterprises to promote development and practical application.

In the course of developing new machines and technologies, rather than adding on multiple functions, we should focus on the practical needs of its users or improve durability. In doing so, we should be able to lower production costs and gain better acceptance among farm managers.

(3) Areas where robots can be promoted (priority areas)

We have selected below areas we believe the development and introduction of robots should be accelerated in the area of agriculture, forestry fishery, and food industry from the perspective of securing labor and significantly improving production.

We should not forget that in developing robots for this industry, the simple development of robots is not sufficient, but that it is important to develop and introduce them as a system, including the processes before and after its development and provide an environment condusive to achieve this.

1. Work automation utilizing an automated GPS cruising system
   Expand work limitations and capture scale merits to lower production costs by allowing agriculture machinery such as tractors to operate at night, have multiple machines operating simultaneously, achieve unmanned operations and automated forward operation for logging, etc.

2. Mechanize and automate labor extensive operations
   Alleviate hash labor with the use of power-assist suits for carrying and

transporting harvested produce. Other examples are weeding robots, robots for planting and nourishing trees, robots for culturing nets and ship bottom scrubbing, preparing lunch boxes, automated milking and feeding systems, etc. In this way, robots can be used to alleviate harsh, dangerous, and repetitive labor.

3. Labor saving and high quality production with the coupling of robots and sophisticated sensor technology
   By combining sensor technology and sophisticated cultivation (sophisticated agriculture) based on past data with the useful knowhow accumulated by the farmer, we can maximize the potential in agriculture, forestry, and fishing in the form of higher yield levels and improvement in quality.

We will focus on promoting the development and recognition of innovative technologies to resolve issues in this field of endeavor.

(4) Our vision for 2020 (KPI)

Robots which have led to resolving issues or achieved breakthroughs will be targeted for commercialization and real world application by 2020 in the areas of agriculture, forestry, fishing, and the food industry.

(Specific examples)

1. Work automation utilizing an automated GPS operated system
   - Promotion of a joint system of man-operated and automated tractors or the practical application a technology for multiple simultaneous operations
   - Promotion of an automated forward logging operation that can autonomously on a forestry work road

2. Mechanization and automation of labor extensive operations
   - Promotion of robots and power-assist suits for harvesting vegetables, the automated milking and feeding of cattle, removing unwanted brush and tree-planting for forestry, robots and power-assist suits for culturing nets and ship bottom scrubbing for fishery
   - Practical application of robots in weeding embankments and ridges between rice fields or the preparation and arrangement of lunch boxes; the miniaturization and weight reduction of power-assist suits; and the sophistication of automated milking and feeding systems.

3. Power saving and high quality production achieved by combining robots and sophisticated sensor technology

- ➢ Sophisticated environmental control systems (temperature, CO_2 levels, concentration levels of liquid fertilizers, etc.) for protected horticulture; robots to select damaged fruit during the processing stages; and robots to determine the quality of raw timber.
- ➢ Practical application of a uniquely Japanese environmental control technology using the analysis of big data

To achieve these, establish/improve the environment needed to introduce robots, including formulation of rules for securing specifications to be standardized and safety and establishment/improvement of communication infrastructure and land foundation, while cooperating with the robot industry, etc.

Through these efforts, contribute to doubling the income of the whole agricultural industry in the coming decade, as indicated in the "plan for generating energy for the agriculture, forestry and fisheries industry and the local communities."

The following indexes are set as the KPIs for assessing the progress of these efforts.

- ➢ Achieving the field installation of self-propelled tractors by 2020
- ➢ Introducing at least 20 models of new robots that will contribute to energy-saving, etc. in the fields of agriculture, forestry and fisheries industry and food industry

(5) Measures to achieve the objectives

(Research and development)

- Robot technology development in the agriculture, forestry and fisheries industry and the food industry (robot technology development demonstration project in the agriculture, forestry and fisheries industry [Ministry of Agriculture, Forestry and Fisheries], Cross-ministerial Strategic Innovation Promotion Program [Cabinet Office])
  Support research and development through cooperation with different fields such as robot engineering toward the adoption of robot technologies in the fields of agriculture, forestry and fisheries industry and food industry by identifying the needs, etc. for technology development in the agriculture, forestry and fisheries industry and the industrial circle.
- Providing opportunities for matching the needs in the agriculture, forestry and fisheries industry and the food industry with the seeds in the robot industry and universities

(Demonstration of the introduction in the field)

- Demonstration of the introduction of robot technologies in the fields of agriculture, forestry and fisheries (robot technology development demonstration project in the agriculture, forestry and fisheries industry [Ministry of Agriculture, Forestry and

Fisheries])

Promote commercialization of robots at prices that allow introduction in the robot field through efforts such as supporting the introduction of those robot technologies coming to a standstill before commercialization/mass production in the fields of agriculture, forestry and fisheries in considerable size/area, and demonstrating the advantages such as improved productivity, as well as helping to solve problems with commercialization and mass production such as establishing a technology system with introduction of robots, reducing cost, and securing safety.

(Establishment of environments)

- Establishment of environment for efficiently utilizing robots at farms

  To promote the establishment and optimization of environments assuming robot utilization in the whole system of agriculture, such as standardizing utensils, containers and the like, creating rules aimed at safety assurance for the collaboration between humans and robots, and improving agricultural land to ensure efficient robot operations.

- Development of players who function as mediator to workplaces toward robot introduction

  To construct a mechanism to examine the effects of robot introduction and to broadly diffuse its results while closely involved with actual workplaces, such as diffusion instructors at prefectures and agricultural instructors at Japan Agricultural Cooperatives. At the same time, to carry out activities to promote matching of engineers in agriculture field and industry field and to discover innovative ideas so that technology participation from different fields are promoted

- Construction of new business models

  To promote activities aimed the construction of new business models through cooperation between business corporations with leading-edge technology and motivated agricultural corporations. Also to promote the construction of a mechanism for the sharing of robots among multiple farmers in the region and the work contracting by contractors when introducing robots with a high initial cost.

- Creation of a mechanism where young researchers of different fields actively engage in the development of agricultural robots

  To increase human resources who consider agriculture, forestry, and fisheries industry and food industry as future start-up fields.

Schedule of Regulation, Institutional Reform

Laws & Regulations	Issue
Radio Act	Establishment of new radio wave utilization system that supports robot utilization (Treating of radio wave used for remote controlling and unmanned robot such as the rule of sharing the frequency with existing radio wave systems and the simple procedure for radio station licenses)

Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019
After sorting out required conditions and discussing technological issues at the research group for radio wave used for robots, examine sharing existing radio wave systems through demonstration tests.		Implement necessary measures on the basis of test results		

Laws & Regulations	Issue
The Act on Securing Quality, Efficacy and Safety of Pharmaceuticals, Medical Devices, Regenerative and Cellular Therapy Products, Gene Therapy Products, and Cosmetics	Time and procedure required for approval/certification of medical devices need to be reviewed with the advancement of robotic technology

Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019
Faster review process for brand-new medical devices: 14 months for normal items, and 10 months for priority items Phase up the annual ratio of devices approved within the time frames till they achieve 80 percentile in fiscal 2018				
60%	70%	70%	80%	

Laws & Regulations	Issue
Road Traffic Act / Road Transport Vehicle Act	Electric personal assistive mobility devices are classified as motor vehicle or moped depending on the total displacement or rated power, and they cannot be used on public roads unless the safety standards are met in principle.

Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019 & after
Based on the evaluation results of “Evaluation and Research Committee for Structural Reform Special Districts”, which is planned to be conducted during FY2014, the way to deal with these assistive mobility devices will be considered, including whether to make use of “Special System for Corporate Field Tests”.				

Laws & Regulations	Issue
Laws and regulations related to uninhabited airborne type robots (Aviation Law and the like)	Concrete rule about uninhabited airborne type robots (UAV)

Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019
<Large UAVs>				
Japan joins in the effort to revise international standard for UAV at the International Civil Aviation Organization (ICAO). Domestic legal study is in preparation.				Formulate domestic rules based on international standard
				▲ Revision of ICAO international standard

<Small UAVs>

Grasp the current way of operation, and scrutinize the need for rules enforced by public organs, including regulations

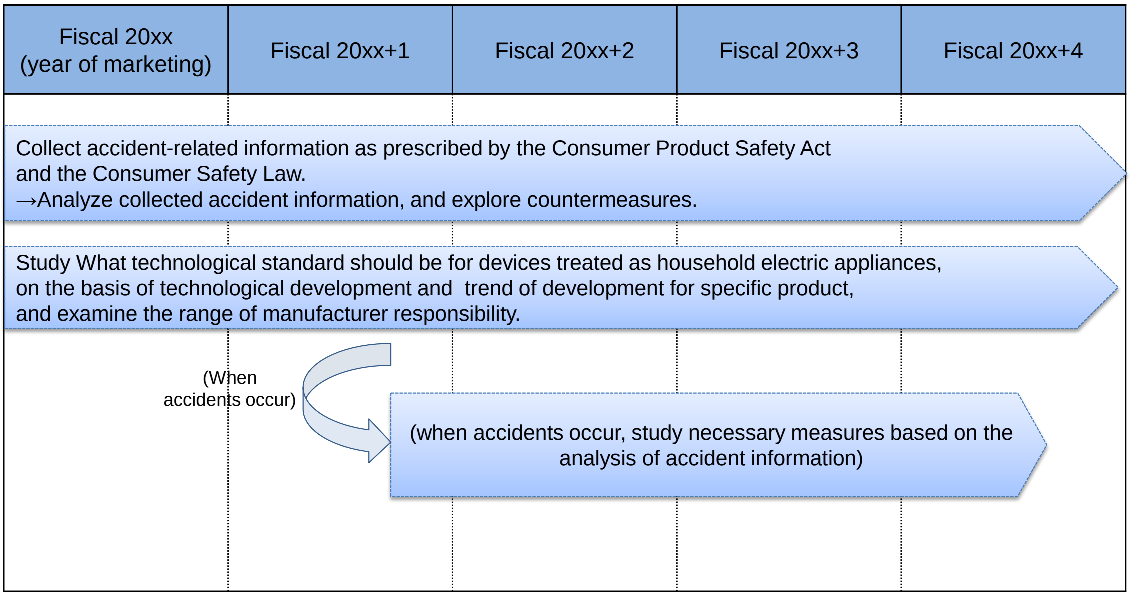
Laws & Regulations	Issue
High Pressure Gas Safety Act	Robot utilization rules with respect to inspection operations, such as visual inspection which are assumed to be performed by humans

Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019
Technological development based on work-site needs Implement test and evaluation utilizing industrial plants, and promote improvement on the basis of on-site needs.				
Consider a system related to inspection by robots, taking into account technological level needed at worksite.				

Laws & Regulations	Issue
Laws and regulations related to public infrastructure maintenance and repair	Effective and Efficient utilization methods of useful robots

Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019
Explore ways to make full use of robots through tests, trials & appraisals by a committee for on-site testing of next-generation robots for public infrastructure maintenance.		Based on the conclusion of the committee, put robots to actual use step by step where applicable.		

Laws & Regulations	Issues
Consumer Product Safety Act, Electric Appliance and Material Safety Act	Consumer safety in the use of new autonomous or remote-controlled household robots for everyday use How to collect information and investigate cause, if and when robots cause serious accidents What technological standard should be for devices treated as household electric appliances, on the basis of technological development and trend of development for specific products. Range of manufacturers' responsibilities.

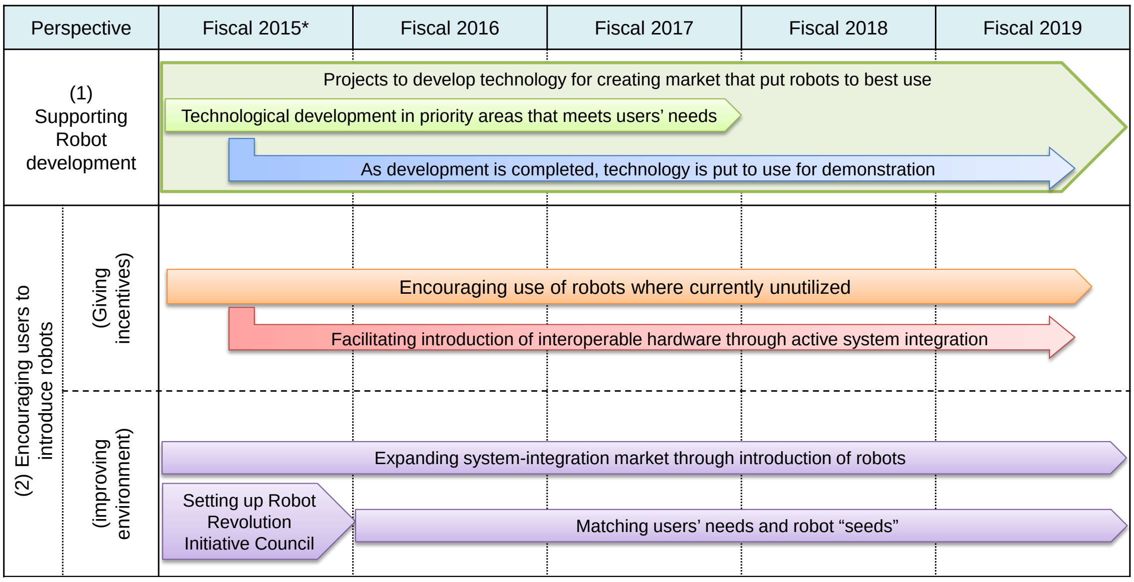


Schedule of Particulars by Sector

1. Manufacturing Sector

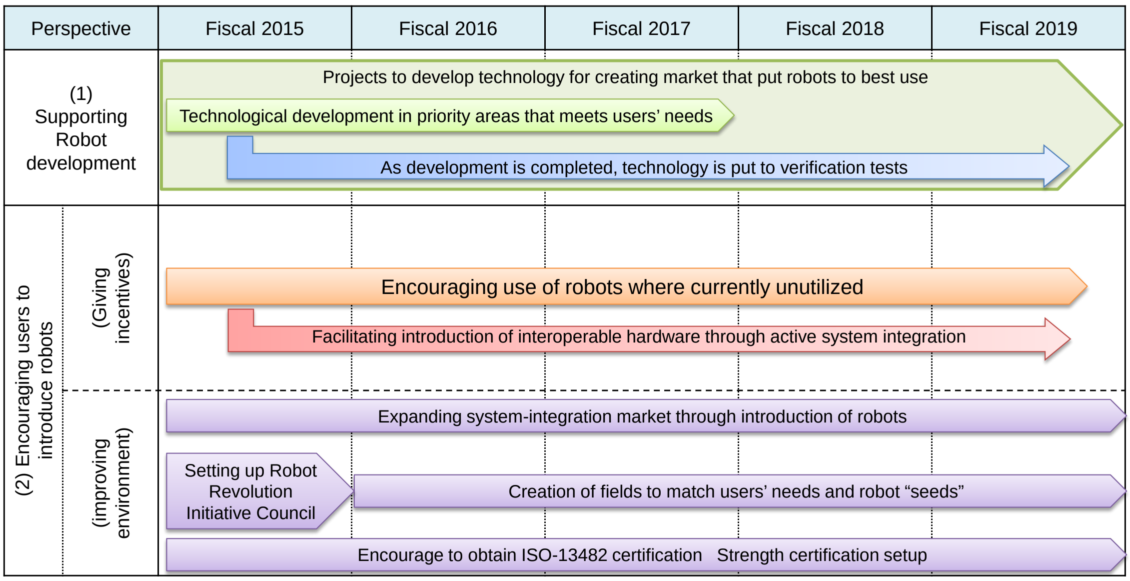
⋆ Fiscal year: April - March

- Aim at greater use of robots in assembly lines (25% for big firms, 10% for smaller companies)
- Collect about 30 best practices in new robot application each year
- Develop and market 1,000 or more interoperable hardware products
- Expand the market related to system integration (at faster growth rate than robot market)



2. Service Fields

- Target at 30% penetration of robots for order picking, sorting, product inspection, etc.
- Collect about 100 best-practice examples of robot use for readying trays of food, cleanup, and other backroom operations in restaurants, hotels, wholesalers and retailers



3. Nursing and Medical Fileds

- Sales target: expand nursing-care robot market to ¥50 billion by 2020
- Change in awareness for new caring methods deploying latest robotics
  Increase the ratio of caregivers who want to use robots to 80% (currently 59.8%)
  Increase the ratio of care-receivers who want robots to be used to 80% (currently 65.1%)
- By using robots for moving the infirm, aim to reduce caregivers' risks of suffering from lower-back pain to zero.
- 100-over projects to assist putting robotics-powered medical devices into practical use in 5 years from fiscal 2015
- Faster pre-market review for brand-new medical devices: 10 months for priority items, 14 months for normal items

Perspective		Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019
(1) Supporting development of robots	care-giving	Support development of care robots in priority areas (projects to develop and promote introduction of care robots, projects to put welfare products and care robots into practical use)				
		As development is completed, technology is introduced on site				
	Medical	Assist development of medical devices using robotic technology				
(2) Encouraging users to introduce robots	care-giving	Develop standards for set up standards for safety, performance and ethics of care robots/review various existing standards			Propose as international standards	
		Encourage to obtain ISO-13482 certification Strengthen capability of certification				
		Create global rules (with EU, etc) for overseas tests and standardization, in view of overseas expansion				
		Provide a field for matching (such as partnerships for care robots)				
		Aim at more flexible reception and inspection of nursing-care insurance application				
		Support introduction of care robots to reduce the burden of caregivers				
	medical	Faster review process for brand-new medical devices: 14 months for normal items, and 10 months for priority items Phase up the annual ratio of devices approved within the time frames till they achieve 80 percentile in fiscal 2018				
		60%	70%	70%	80%	

4. Infrastructure, Disaster Response, and Construction Fields

- 30% use of computer-aided construction technology that boost productivity and save labor
- Increase efficiency of inspection and repair in 20% of important/old infrastructure through the use of sensors, robots and nondestructive testing.
- Performance equal to manned operation even at landslides, volcanic eruption, etc.

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			
	(improving environment)		Based on on-site tests, evaluation, & and trial use, implement "standardization" & "certification of performance and safety", and "review of system"			

5. Agriculture, Forestry, Fishery, and Food Industry

- Introduce self-propelled tractors into worksite by 2020.
- Introduce 20 or more types of robots that save labor and otherwise contributes to the industry.

Perspective	Fiscal 2015	Fiscal 2016	Fiscal 2017	Fiscal 2018	Fiscal 2019
(1) Support development of robots	Grasp the needs of farms, show expected market scale & what special technology is needed.				
	Tackle with such schemes as meetings of engineers from both agricultural and manufacturing sectors, holding robot contest, etc. to dig up revolutionary ideas				
	Feedback				
	Technological development in priority areas that meets users' needs				
(2) Assist introdution of robots	Promote introduction of robotic technology that responds to worksite needs into robot production sites				
	Consider standardizing utensils & containers used in logistics, formulating man-robot safety rules, and furnish grounds where robots can be operated efficiently				
	Create new business models through cooperation between financial & farming sectors, and set up framework for robot sharing among farmers, and contracting farm-work using robots				
	Create a framework in which prefectural agricultural advisors and consultants of Japan Agricultural Cooperatives test the effectiveness of introducing robot in farms, and the results are extensively disseminated				