Robotic Solutions

Building a smart society with state-of-the-art technology
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Living assistance robots → Pages 8-9

● Robotic Bed
A robot that supports an independent lifestyle by combining an electric care bed with an electric wheelchair

● “Reborg Q”
A security patrol robot with specialized security functions that can operate in concert with security guards.

● Universal Vehicle “Rodem”
A mobile health care and welfare robot boarded from the rear on which a rider can maintain either a sitting or standing posture.

● Robotic Suit “HAL®”
A robot that expands, amplifies, and supports physical functions by interpreting the bioelectric signals coming from the surface of the user’s skin to determine the user’s intended physical movement.

● Cleaning Robot
A robot that recognizes its surroundings and automatically cleans floor surfaces in facilities such as office buildings.

● Walking Assist
A robot that provides optimal walking assistance based on information from a hip joint angle sensor gathered while walking.

● “Winglet”
A mobile support robot for a standing rider that can move forwards, backwards, left, and right safely and easily just by shifting one’s body weight.

NEDO is developing robotics technologies with the expectation of practical applications in the fields of lifestyle and social welfare, as well as public services and disaster preparedness. NEDO aims to realize a convenient and comfortable “smart society” where robots are active in various parts of our everyday lives in the near future.
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Robots for special environments → Pages 10-11

● **“Super Giraffe”**
A remotely operated robot that moves freely in areas where people cannot go and can reach locations up to 8 meters high with a robotic arm that has seven articulated joints.

● **“Super Lifter”**
A remotely operated cargo truck for handling heavy objects and delivering them to upper floors with the ability to lift objects up to 4 tons to a maximum height of 30 meters.

● **“Quince”**
A crawler-type rescue robot that can enter areas difficult for humans to enter such as disaster sites and perform a survey of the conditions.

● **“ASTACO NEO”**
A robot that can handle complicated operations by combining a powerful main arm and a secondary arm that assists the main one that function similarly to human’s two arms.

● **Robotic Suit “HAL®” for Disaster Recovery**
A power-assist exoskeletal robot that can operate safely without harming one’s health in environments contaminated by hazardous materials as well as in extremely hot and humid environments.
A 10 Trillion Yen Robotics Market in the Future
Growing to follow automobile and home electronics as the next major industry

NEDO is promoting the development of robots for use in various aspects of society, including our everyday lives, nursing and welfare, and disaster response. Some robots have already been commercialized, and there are also some projects that have been started overseas. Robotic development will also reach a substantial turning point with plans to establish safety standards during the current fiscal year. Shoji Kukita will discuss what sort of role NEDO will play within this process and how the robotics market will develop in the future.

History of NEDO robotics development

<table>
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<tr>
<th>Year</th>
<th>Project Name</th>
<th>Description</th>
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| 2005 | Fundamental Technology Project for Practical Application of Human Support Robots | We developed robots and conducted demonstration tests in three important areas of welfare and nursing:  
- Developed rehabilitation support robots and technologies necessary for commercialization  
- Developed autonomous movement support robots and technologies necessary for commercialization  
- Developed nursing care support robots and technologies necessary for commercialization |
| 2006 | Development Project for a Common Basis of Next-generation Robots | We developed RT critical components for installation on robots as well as a fundamental communication module for linking RT critical components and a network. Then we built a household RT system that combined these elements, and tested its efficacy.  
- Developed fundamental communication modules and RT critical components  
- Developed and tested RT systems based on RT critical components |
| 2007 | Project for Strategic Development of Advanced Robotics Elemental Technologies | Development of necessary robotics systems and elemental technologies to achieve the seven missions born from the needs of market and society.  
- Manufacturing robotics area  
  (1) Develop manufacturing robots that can handle flexible, fragile objects  
  (2) Develop human-robot cooperative cell-type assembly systems  
- Service robotics area  
  (3) Develop robots for clean-up operations  
  (4) Develop communication assistance robots for the elderly  
  (5) Develop transportation robots  
- Special environment robotics area  
  (6) Develop robots for moving inside buildings damaged in disasters  
  (7) Develop robots for disposing industrial waste related to construction |
| 2008 | Intelligent RT Software Project | In order to be able to develop high performance robots efficiently at a low cost, we developed and tested the effectiveness of common components (modularization) for a range of intelligent software that functions as the “brain” required for a robot to perform tasks such as movement, communication, and work.  
- Develop robot intelligence software platforms  
- Develop modular-type intelligence technologies  
- Test the efficacy of these technologies |
| 2009 | Fundamental Robotic Technology Utilization |  
| 2010 | Living Assistance Robot Practical Application Project |  
| 2011 |  
| 2012 |  
| 2013 |  

Development of safety standards and enough technology would lead to a wide variety of robots being on the market and for them to become a pillar of the economy, as the automobiles and home electronics industries are to society today. The robotics market is expected to expand to a 10 trillion yen market by 2025.

Research and Development Project for an Unmanned Disaster Response System

Rehabilitation support
Nursing care support
Autonomous movement support

Development of robot intelligence software platforms  
- Develop modular-type intelligence technologies  
- Test the efficacy of these technologies
2014 Will be the “first year of the robot” with the establishment of safety standards

– We have heard about NEDO’s early involvement in robotic development. Please begin by telling us about that history.

Kukita: NEDO’s robotic development began 25 years ago in 1988, when we took over responsibility for industrial technology development from the Agency of Industrial Science and Technology at the Ministry of International Trade and Industry (MITI). At the time the focus was robots doing tasks where humans could not go, not on personal robots as now. In order to discover robotics’ potential we took an across-the-board strategy.

This changed dramatically after the Aichi World Expo in 2005. As our focus moved towards full-fledged commercialization, NEDO launched the Next-Generation Robot Commercialization Project and Living Assistance Robot Practical Application Project one after the other. In particular, our current focus is on living assistance robotics.

– Although living assistance robots could be seen at various expositions in recent times, it seems that they have not been widely commercialized. What might be the reason for this?

Kukita: There are a variety of reasons like the small market size and high prices, but the fact that safety standards have not been established is a substantial factor. We are in the process of developing robot safety standards that would be based on certification by third parties, and we are making the shift to ISO by the end of this fiscal year. If we can do this, I think that the robot market will grow and the year of 2014 might become the “First Year of the Robot.”

Market expansion predicted in the field of lifestyle support robotics

– How much will the robotic market grow in the future?

Kukita: Although the current living assistance robotic market is on the scale of several billion yen, we see the potential for the market to grow to roughly 5 trillion yen by 2035.

![Projected robot industry market by 2035](image)

Shoji Kukita
Director General, Technological Development Promotion Department, NEDO

**PROFILE**

After graduating from Sophia University with a law degree in March of 1980, he entered the New Energy and Industrial Technology Development Organization (NEDO) in October of the same year. After serving in Accounting Department, International Affairs Department, General Affairs Department, Representative Office in Bangkok and Machinery Systems Department, he began serving in his current position in July 2011.
A public presentation of robotics technologies related to disaster response in nine fields from February 2013. These technologies were developed through NEDO’s “Research and Development Project for an Unmanned Disaster Response System” with commercialization in mind.

– What has the current status robots for use in hazardous environments become?

Kukita: A variety of robots have been developed at a rapid pace due to the accident at the Fukushima nuclear power plant. Furthermore, given that these robots can be utilized in other work settings, I think the numbers will grow from now on. In addition, since policies have been put in place to strengthen national infrastructure after the Chuo Expressway tunnel accident, NEDO is also considering the development of robots to check infrastructure and make repairs. Of course we won’t only use these robots for public infrastructure, but also plan to enable them to work in various situations such as accidents at industrial complexes. We believe that this market will be extraordinary large and could reach a total market size of roughly 10 trillion yen, becoming a major industry in line with the auto and home electronics industries.

– What has the current status robots for use in hazardous environments become?

Kukita: Since NEDO has conducting a range of development activities we can apply these management techniques to robots as well. For example, we have a varied menu of possibilities, including managing the practical applications and commercialization of technologies as well as supporting startup businesses. There are cases where a hospital and a private company want to engage in a joint project and sometimes the hospital might hesitate to proceed, but there have also been cases where things went smoothly because NEDO facilitated the process. This has also occurred overseas. Even when companies proceed alone there are cases when their partners just will not cooperate, but there have been instances where NEDO intervenes and things go much better. I think that the current projects we are promoting in Germany and Denmark are typical of this approach. We have begun this overseas first because it would be difficult to implement these two particular projects in Japan due to regulatory obstacles. In the future, we want to steadily increase the number of overseas projects.

– With regards to the expansion of robot use, what kind of activities is NEDO considering to carry out?

Kukita: The first thing will be demonstrations. Since we believe that it is extremely important for people to have first-hand experience, we want to actively display these products at venues such as expositions. Furthermore, in terms of legislation, we are considering various suggestions from the perspective of both users and the manufactures. Eventually, when people say robots we want them to think of NEDO, and when people say NEDO we want them to think of robots, and we want to continue trying to develop this link.

### NEDO's strategy to expand robot use

– What is the significance of NEDO’s involvement with robot development?

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Global development of robotic technology

In order to diffuse robotic technology globally, it is essential to quickly demonstrate the technologies and get the results.

Currently, demonstration tests are being conducted in Germany in collaboration with the startup company CYBERDYNE Inc. to explore possibilities for coverage by general medical insurance for the CYBERDYNE-developed medical-use robotic suit HAL® at a German hospital. If the coverage is approved, it might lead to a rapid growth in the number of units sold, spreading widely in Europe.

In addition, we are planning a demonstration project in Denmark to test a unique electric wheelchair developed by Tmsuk Co., Ltd., a small to medium-sized company, as well as a nursing care robotic system that uses NTT DOCOMO communication features and can operate in the homes of elderly people and nursing facilities in a way that offers convenience for caregivers and safety and security for persons receiving care.

In order for the use of robots to expand, it is important not just to sell machines but to also provide a set of new services that take advantage of the machines. Just as in the current project we are conducting, by offering things like nursing services in combination with the robots we believe that we can create new value.

Robotic Suit “HAL®”

Robotic Suit HAL® assists the movement of the legs appropriately when walking, standing, or sitting by using built-in sensor data to recognize the motion state of the wearer and analysis of minute bioelectric signals that reveal when the wearer intends to move. At the moment, there are 361 robotic suit HAL® units in operation for welfare use at 157 facilities in Japan.

<table>
<thead>
<tr>
<th>Item</th>
<th>Specifications</th>
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<tbody>
<tr>
<td>Weight</td>
<td>Two leg model: approx. 12 kg; One leg model: approx. 6 kg</td>
</tr>
<tr>
<td>User Height</td>
<td>145–185 cm (approximately; S/M/L sizes)</td>
</tr>
<tr>
<td>Foot size</td>
<td>22–28 cm (sensor installed)</td>
</tr>
<tr>
<td>Power supply</td>
<td>Li-Po battery</td>
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Universal Vehicle “Rodem”

Rodem is a living assistance robot based on an electric wheelchair with a new mechanical system that reduces the physical burden placed on both patients and caregivers and avoids dangers while in motion, enabling free and safe movement of patients.

- Simple and safe self-boarding
- Allows an expanded range of movement
- Enables an independent lifestyle

Robot testing in Germany

Electric wheelchair by Tmsuk Co., Ltd. with testing planned in Denmark. Built with a new structure and system that makes boarding and riding easy and safe while expanding the rider’s range of movement.

Yoshiko Yurugi
Chief Officer
Technological Development
Promotion Department, NEDO
Taking a big step towards commercialization

Living Assistance Robot Project

This year is the last year of the “Living Assistance Robot Practical Application Project.” For five years NEDO has been working on a variety of issues as part of this project. As a result, Japanese living assistance robotics has made great strides forward and now is on the verge of commercialization. The age of robots expanding to become a household item is near at hand.

Inaugurating new robot safety center for various tests

In Japan there is a concern about a labor shortage in fields such as nursing as the population continues to age while birthrates decline. NEDO has been working on the “Living Assistance Robot Practical Application Project” since 2009. This project can largely be broken into three stages. The first stage was the development of robot safety technology, the second stage established testing technologies to verify safety, and the third stage is the international standardization of the developed technologies.

As part of the second stage we built the Robot Safety Center in Tsukuba in Ibaraki Prefecture and we are conducting tests using various robots provided by approximately 20 participating companies. There are 18 categories of tests including, for example, collision safety tests, level road running tests, sloped road running tests, and impact resistance tests. We aim to establish test technologies to verify robot safety based on this collected data.

Businesses want to build safe and reliable robots because users want them, but businesses can’t build safe robots without safety standards. That’s why this testing technology is extremely important. Eventually, as robots that have been through safety testing at the Robot Safety Center hit the global market, we would like to make this center a Mecca for living assistance robot safety technology.

In terms of international standardization, ISO is currently deliberating on the standards and publication is planned by the end of this fiscal year. As part of the ISO process we have made various proposals based on the testing data we have collected up until this point, playing an important role in forming international standards.

Diagram of the robot safety center and the safety verification system
Delivering robots into the hands of everyday people in five years

Although we have many issues to deal with on the business side of things in comparison to technological development, we anticipate that the Japanese robot business will accelerate rapidly if ISO standards are completed. In fact, we hear that there are companies planning to enter the market with living assistance robots next year. We expect that in five years costs will come down and it will become feasible for the general public to buy these robots. Nonetheless, we think that it will be difficult to sell large quantities of robots through home appliance retailers. This is because it is crucial for robots to be developed and adjusted to suit the individual user’s body, symptoms, and required degree of care.

We think that local governments will play an important role in the popularization of robots. Many local governments are already dealing with the expansion of things like adult day services and welfare devices, and some local governments have staff with the responsibility of promoting the robot industry. At NEDO we are building networks with these local governments and exchanging a variety of information with them.

In addition, NEDO launched a program called the Robot Care Equipment Development Partnership and serves as the coordinating organization. This partnership offers a place where facilities with healthcare needs and companies that offer technologies can interact, and currently has 130 participating companies mostly made up of small and medium-sized enterprises. Furthermore, in addition to matching services we provide various services including information sharing with government agencies, building networks between companies and researchers, and collecting feedback on future policies to promote the application of robotic nursing care devices.

NEDO would like to continue providing a variety of support for the development and commercialization of living assistance robots going forward.

Examples of project robots

**Mobile task robots (manually controlled)**

1. Robotic Bed: Panasonic Corporation

   - Maximum weight load testing
   - Impact resistance testing
   - Anechoic chamber testing
   - Complex environmental testing
   - Static stability testing

2. (2) Daifuku Co., Ltd.

3. (3) Hitachi Industrial Equipment Systems Co., Ltd.

**Mobile task robots (autonomous)**

- Crash safety testing
- Simulated object avoidance testing apparatus
- Anechoic chamber testing
- Environmental recognition performance testing
- Multipurpose driving testing

**Wearable robots for humans (attached)**

4. (4) Robotic Suit HAL®: CYBERDYNE Inc.


- Maximum weight load testing
- Impact resistance testing
- Belt operational durability testing
- Anechoic chamber testing
- Complex environment testing

**Riding robots**

6. Passenger robot: Toyota Motor Corporation

7. Electric wheelchair: Aisin Seiki Co., Ltd.

8. Outdoor mobility assistance device: IDEC Corporation

- Maximum weight load testing
- Impact resistance testing
- Simulated obstacle avoidance testing apparatus
- Complex environment testing
- Anechoic chamber testing
Aging Public infrastructure enhancing the demand for Field Robot Developing

Triggered by the March 2011 nuclear power plant accident, the development of robots to work in special environments is progressing. NEDO is developing disaster response robots for use not only with nuclear reactors in mind, but also various natural disasters and a range of industrial facility accidents. We also anticipate applying robotic technology to inspect and maintain aging public infrastructure.

Collaborative work between robots becoming possible with increased compatibility in communication technologies and interfaces

Alongside our development of living assistance robotics, NEDO is investing energy in the development of robots for use in special environments. Last year we allocated approximately 1 billion yen to implement the “Research and Development Project for an Unmanned Disaster Response System”. This project was started with the accident at the Fukushima nuclear power plant in mind.

Although we had supported development of robots for use in special environments in the past, since each company developed their own robots independently we were not able to use them collaboratively. For that reason, this time we decided to develop common robotic systems that every company could use.

With NEDO at the core, we promoted unified development by organizing a consortium of businesses and universities including Chiba Institute of Technology, Hitachi, Ltd., Toshiba Corporation, Mitsubishi Heavy Industries, Ltd., Mobile Robot Research Co. Ltd., and CYBERDYNE Inc. Then we enabled multiple robots to work collaboratively by standardizing communication technologies and remote operation interfaces.

For example, by watching the video feed produced by one robot to control the work of another robot, we can enable operations to proceed more accurately and smoothly.

We have also developed gamma cameras, mobile devices that can operate in the water, mapping systems to help visualize temperature and radiation intensity, and robotic suits that people can wear to facilitate hazardous work. These types of robots can operate cooperatively with other robots.

In the beginning each company had their own separate ideas and it was extremely difficult for them to share with other companies. But based on our past lessons learned, we were able to convince the companies to work openly on areas that could be opened as much as possible and work towards mutual interoperation.

The technology developed as part of the current project has garnered significant attention, and we have received many inquiries wanting to learn about this technology, some even coming from overseas.

Utilizing Robots in More than Just Disaster Areas: Inspecting and Maintaining Public Infrastructure

The robots we developed this time for use in special environments are not limited to just nuclear power plants, and NEDO hopes to use these systems at a variety of disaster sites such from natural disasters like earthquakes and serious accidents.

Also, this robotic technology can be utilized to deal with failing infrastructure and in harsh environments other than nuclear power plants. Although there are many pieces of public infrastructure that are extremely old and performing inspection and maintenance is a necessity, there is a limit to the work that people can do. NEDO would like to focus our efforts on these types of robots, because if we can develop these robots, they can become strong allies to human beings.

In the future we anticipate robots being used not only at various disaster sites but also for inspection and maintenance jobs at plants and public infrastructure where up until now the work would have been difficult without people.
Disaster response robots that can work collaboratively in special environments

- Remotely operated cargo truck for handling heavy objects
  - Super Lifter developed by Toshiba Corporation can lift large robots like Mitsubishi Heavy Industries’ aerial work platform up to 30m vertically.

- Remotely operated crane/platform for working with heavy objects in narrow locations
  - “MH-Super Giraffe (MARS-C)” developed by Mitsubishi Heavy Industries, Ltd. Can reach up to 8m high.

- Communication technology
  - Hitachi, Ltd developed communication system that enables wireless communications in special environments.

- Remote operation human interface
  - Remote operation human interface developed by Toshiba Corporation. Robots are controlled via a game controller.

- Disaster response robot control practice simulator
  - Disaster response robot control practice simulator developed by Chiba Institute of Technology.

- Gamma camera
  - Gamma camera developed by Hitachi, Ltd. Able to take measurements even in the presence of high radiation emissions.

- Contamination mapping technology
  - Contamination mapping technology developed by Chiba Institute of Technology. Able to display data measured by gamma cameras and other devices as 3D imagery.

- Compact high mobility remotely operated unit (Mobile robot for advanced survey of narrow spaces)
  - “Sakura” mobile robot for the advanced survey of narrow spaces developed by Mobile Robot Research Co. Ltd. The successor to “Quince,” it was made more compact and was used to enter the Fukushima Daiichi nuclear power plant.

- Amphibious mobile unit
  - Amphibious mobile unit developed by Toshiba Corporation that can even move underwater. Can be equipped with sensors and cameras.

- Disaster response task assist robot
  - Robotic Suit “HAL” for disaster recovery developed by CYBERDYNE Inc. Enables manned operations while considering worker safety even under harsh environmental conditions with high heat and humidity.

- “Tsubaki” mobile robot equipped with a weight measurement device developed by Mobile Robot Research Co. Ltd. Made to be more powerful than the “Quince” model.

- “Sakura” mobile robot for the advanced survey of narrow spaces developed by Mobile Robot Research Co. Ltd. The successor to “Quince,” it was made more compact and was used to enter the Fukushima Daiichi nuclear power plant.
Demonstration tests of the robotic suit “HAL®” launched in Germany

- Project by NEDO and the North Rhine-Westphalia Ministry of Economic Affairs and Energy -

NEDO and the North Rhine-Westphalia Ministry for Economic Affairs and Energy began demonstration tests of a robotic medical device intended for a broad range of applications in clinical practice. The wearable robot “HAL®”, developed by CYBERDYNE Inc. as part of a NEDO project, was introduced to a hospital in the city of Bochum, where tests have been conducted to demonstrate how the device could meet local medical needs. The hope is that public health insurance plans might cover the device and that its use might expand throughout Europe.

Prior to the start of the demonstration tests, Kenji Kurata, NEDO President, and Garrelt Duin, Minister for Economic Affairs, Energy and Industry of the state of North Rhine-Westphalia, Germany, signed a corresponding agreement for demonstration in Bochum.