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Japan’s Decline as a Robotics Superpower: Lessons From Fukushima

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Introduction

Robots were a major force in the automation drive that made Japan the most competitive nation in manufacturing in the 1980s. That glory seems to have faded in recent decades, and Japanese robotics are no exception.

The two articles that follow highlight the failures of R&D in Japanese robotics engineering that were dramatically and tragically revealed by the earthquake and tsunami-driven meltdown of TEPCO’s nuclear power plants at Fukushima. Contrary to expectations that Japan would be a leader in manufacture of disaster relief robots that could have been used in problem solving and cleanup in the wake of the Fukushima Daiichi nuclear disaster, three months after 3.11, Japan’s robots have yet to make a significant contribution. These articles explain why Japan, in general, its robotics industry in particular, proved unprepared for severe nuclear accidents, and how haphazard the government and the nuclear industry has been in developing robots that could have eased the crisis.

The Nikkei article published on May 16 focuses on structural problems within the Japanese robotics industry, while the Kyodo article published on June 9 deals with the interface between the Japanese government, TEPCO and the robotics industry that resulted in the current impasse, forcing Japan to turn for assistance to the US robotics industry.

The heart of the problem is this: it is necessary for any kind of robot to be tested and improved repeatedly before it can be used in real life situations. But for disaster relief robots, it is difficult to find an appropriate milieu for repeated testing without actually going to disaster sites. Strong support from the government is crucial here, but because the Japanese government chose to cling to the nuclear safety myth, it remained in a state of denial about the necessity for disaster relief preparation. Thus Japan’s much-vaunted robotics industry was unable to respond to the Fukushima challenge.

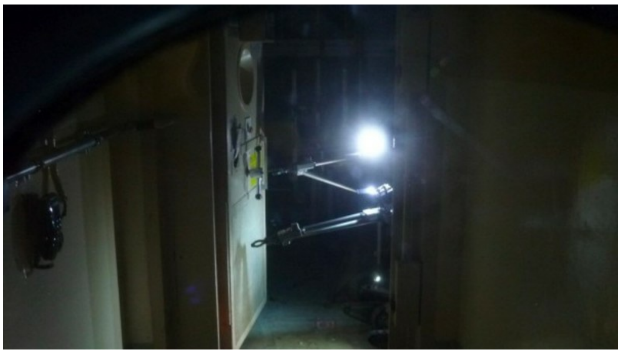
Robots to be used effectively in nuclear accident sites must be radiation resistant. Electronic components are vulnerable to radiation. Microcomputers may malfunction, and power electronics may short circuit. This is seldom a problem for industrial robots. Rather, it is a special feature for military and aerospace electronics. Japanese industries, which have generally distanced themselves from military technology thus have little or no experience in this field where US robotics lead. In any event, it is difficult to shield robots against extremely strong radiation involving nuclear fuel meltdown. That is why Chernobyl needed so many human liquidators and why human liquidators bear the brunt of the work at Fukushima.

As Kyodo News reports, despite efforts to develop appropriate robots in the wake of 1999 disaster at Tokai, the project ground to halt in part because of the preference by both TEPCO and the government to emphasize the safety of nuclear plants. SY.

"Robotics Superpower, Japan": Fiction and Fact. Why Japanese-made Robots Play No Role in Nuclear Plant Operations

Many Japanese were disappointed that no Japanese-designed and -produced robot was used at the Fukushima nuclear accident site. Japan’s long pre-eminent place in the industrial robot market has been eroded by emerging economies, while personal assistance robots, seen as the next market for Japanese robotics, have yet to bridge the risky gap between research and commercialization. Then, what is necessary for the resurrection of Japan as a Robotics Superpower?

On April 17, an image released to the press showed a PackBot robot entering the crippled reactor building of Unit 1 of the Fukushima Daiichi nuclear plant. PackBot is a military robot developed by an American hi-tech company known for its popular house cleaner robot, "Rumba."



Remotely operated by TEPCO workers, at 11 a.m that day, the PackBot entered the turbine buildings of Unit 1 and 3, then opened the double doors to go into the reactor buildings, measuring radiation levels, temperature, humidity, and oxygen concentration, before coming back out.

When Mr. Mano Takahisa, acting manager at the Manufacturing Science and Technology Center heard the news, he had mixed feelings because his colleagues flooded him with email and telephone calls asking, "Why didn't they let Japanese robots go in first?"

Mr. Mano flashbacked to the names of radiation-resistant Japanese robots in which he had been proud to be deeply involved 10 years ago: "The Smart", "Mars", "Swan", and "Menhir". "If those robots still existed, would they be working in the Fukushima plant right now?" he wondered.

The Fate of Four Types and Six Units of Robots

In January, 2000, the then Ministry of Economy, Trade and Industry allocated ¥3 billion for the development of "nuclear disaster relief systems". Mr. Mano’s Manufacturing Science and Technology Center, an affiliated organization of the Ministry, received a budget and issued a call for tenders for participating firms. Mitsubishi, Hitachi, Toshiba, and the French firm, Cybernetics, submitted tenders and started work in June of that same year to develop four different types of robots, six units in total.

The previous year, on September 30, 1999, a critical nuclear accident occurred at a nuclear fuel processing plant run by JCO in Tokai-mura, Ibaraki Prefecture. The uranium solution reached criticality creating a chain reaction that released a neutron beam which killed two nearby workers. The Tokai-mura accident prompted questions about whether robots rather than humans could work in such high radiation, hazardous conditions. "These voices initiated the project to develop radiation-resistant robots," Mano says.

At that time, as an assistant section manager, Mano negotiated with the manufacturing firms. "There are a wide variety of tasks in handling accidents in nuclear power plants or related facilities. No single robot can do all these tasks such as cutting pipes and draining water, opening/closing valves, taking irradiated samples," he says. Thus, multiple types of robots were designed and development started according to the engineering strengths of individual firms.

The Smart robot developed by Toshiba was a unique system consisting of two units, a small robot on a larger carrier, intended to enter a site first and gather information. Hitachi's Swan handled light work such as the opening/closing of valves and sample collection of reactor cooling water. Mitsubishi's Mars was a twin robot system each cooperating with the other, able to open doors, go up and down stairs carrying heavy loads up to 50kg. Cybernetics' Menhir had the highest radiation-resistance, and with two arms, it was able to move heavy obstacles and cut pipes.

Japan Unable to Bridge the Gap Between Development and Operation

Because the budget was limited to one fiscal year, the development work was carried out hastily with prototyping completed in about seven months. The demonstration runs took place barely within the set time of one fiscal year, occurring on March 22 and 23, 2001. However, after the demonstration runs, the six robots had miserable fates.

In the following year, the six robot units were sent for field testing and evaluation. The conclusion given by the industry, including TEPCO, the Electric Power Industry Central Research Institute and the Japan Nuclear Cycle Development Institute was that "there is much room for improvement and these robots are not suitable for immediate deployment." They raised a number of reasons for their conclusion, including the low reliability of remote control and the excessively large size of machines meant to move around in the small spaces of reactor buildings,,but it is most likely that their conclusion came from an underlying anti-robot opinion evident in the statement "it is quicker and easier to send personnel there while ensuring their safety."

Mr. Sanji Shinichiro, a researcher who specializes in robotics at the Mitsubishi Research Institute, points out that "new machines only become suitable for practical use after trial use and error. Perhaps there is a pre-existing conclusion that robots are unnecessary because the argument that they are necessary might challenge belief in the safety of nuclear plants."

Toshiba's Smart robot was transferred to the Tokyo Fire Defense Agency without charge around 2003, but its current whereabouts is unknown. The French Menhir was accepted by Professor Tadokoro at Tohoku University’s Department of Engineering. Tadokoro is a specialist on rescue robots, and the robot was put on display in a university building. Prof. Tadokoro also accepted Hitachi's Swan, but was unable to find a place to store it. He then received an offer from a science museum in Sendai to display the robot in a children's robot corner, and the robot was transferred to Sendai for free. It is still on display there, but "due to safety concerns, it was modified to be inoperable," says a museum spokesperson. Mitsubishi's Mars was disassembled and the parts reused for other projects.

"Since these robots were custom made, maintenance alone is costly. To keep these machines operable all the time, it is also necessary to maintain a skilled workforce and educate them in the complex skills required to operate the robots. The one-year budget did not fund maintenance of the robots," notes Mano. He says that when he saw Mars disassembled, tears welled up in his eyes.

The one-shot budget had produced development and left behind a thick bundle of reports without putting anything into practical use. The experience of trial-and-error certainly remains an asset, but there's no future. Examples of other national projects ending up like this are easy to find.

While the world competes for advantage in the technology stakes, Japanese-made robots are not being used. What's lacking? There is a sequel to the story of Japanese robots that symbolizes the structural problems that have a hold on Japan.

The French designed Menhir robot developed for Japan ten years ago is now covered with dust in a Tohoku University building. However, at the same time as Cybernetics developed Menhir and using the same design, it manufactured the "LMF" robot and exported it to Germany. The LMF is still working in Germany now.

The company which owns the LMF is a private nuclear technology assistance firm, KHG. Nearly 90 percent of its shares are in the hands of a holding company consisting of three major German electric companies EON, EnBW, and RWE. About thirty expert operators are routinely trained for protection against radiation, remote operation of robots, and decontamination procedures. France has a similar nuclear disaster prevention company, funded by EDF (50%), the Atomic Energy Agency (35%), and the nuclear fuel company, AREVA (12.5%). Since the Chernobyl accident, a nuclear accident is seen as "an imminent threat" for European electric companies. Hypothesizing a worst-case scenario, developing robot technology as the next option, is "appropriate risk management."

Defense Budget Breeds Robots in the US

In the US, where the PackBot that went into the Fukushima No 1 plant was born, there is also an incubator to develop and operate nuclear disaster relief technologies: the defense budget. "PackBot relieved soldiers of dangerous operations and saved many lives," says Colin Angle, CEO of iRobot.

The Afghan war intensified in 2002, and the Iraq war broke out in 2003. In the battlefield, PackBots and the Small Unmanned Ground Vehicle (SUGV) were first put into operation to break into caves where enemies were hiding, or to dispose of roadside explosives. Although a PackBot costs USD$120,000 per unit, while an SUGV costs USD$130,000 to 200,000, "more than 3500 units in total were sold to the military" said CEO Angle.

In the US it is not unusual to find hi-tech companies like iRobot heavily dependent for their existence on the military. Kinetic and Remotech are also developing military robots. A huge amount of the annual US defense budget of USD$660 billion is poured into these hi-tech companies to fund research.

Mr. Sanji points out that "Japan has insufficient patrons to fund the development of disaster relief robots, and there are no operators to maintain and train the robots." Power companies in Europe and the military in the US clearly play the role of patrons, and they are tightly coupled with the operators by capital and trading relationships. In Japan, however, the government spends some development budget on occasions like the JCO accident, but these expenditures and developments never take root as a disaster prevention system.

"Probably the Fukushima nuclear accident will again draw attention to nuclear disaster prevention, and some budget will be allocated. But since there's no organization responsible for the operation, it is likely to end up in the same pattern as the JCO accident," Mr Sanji speculates.

The mythical assumption of nuclear safety shows no sign of collapsing. Yet preparing a next option for accident management doesn't mean that the myth of nuclear safety is undermined. This is an obstacle for not only the nuclear industry but also for the Japanese robotics industry; one that must be overcome in order to move to the next stage.

Myth of Nuclear Safety Sets Back Robotic Research and Development

Kyodo News

On March 17, six days after the crisis erupted at the Fukushima No. 1 nuclear power plant, a list was presented to Washington through diplomatic channels seeking U.S. assistance.

Headlining the list was a request for robots — specifically, ones that could remove wreckage and measure radioactivity levels — as well as devices to inject water into the plant's reactors.

Packman: A PackBot, U.S.-made remote-controlled machine, opens a door to the main reactor building of unit 2 at the Fukushima No. 1 nuclear plant on April 18.KYODO/TEPCO

The list was compiled after consultations with Tokyo Electric Power Co., the Nuclear and Industrial Safety Agency and other ministries and agencies.

"It was like a list asking the United States for a favor. It was the result of their realization that they could not deal with the crisis on their own," a Foreign Ministry source said.

Since then, countermeasures using foreign technological assistance have been initiated.

The first robot to go into one of the plant's reactor buildings, where high radiation was measured after the accident, was a U.S. PackBot. Japanese-made robots, said to be the best in the world, were not at the vanguard of such a crucial event.

This has begged the question: Where has the country's pride as a scientific and technological giant gone?

Sakigawara Masahiro, head of the Future Robotics Technology Center at Chiba Institute of Technology, said, "The PackBot is mass-produced for assignment to war-ravaged areas. There are only a few dozen trial Japanese robot models. Their functions are fundamentally different."

The recent decision to assign the Quince robot, which the institute's team helped design, marked the first time a Japanese-made robot was sent to the troubled Fukushima plant. But preparations for the practical use of the robot — which has won several world competitions for running over wreckage — including compiling user manuals and confirming whether it could withstand high radiation levels, took time.

"Japan's research and development feature specializing in and mastering one capability," said Nakamura Yoshihiko, professor of robotics at the University of Tokyo. "The Japanese are not good at integrating more than two capabilities and raising them to 'usable standards.' "

A similar story can be heard regarding the disposal of water contaminated by radioactive materials in the crisis.

The facilities at the Japan Atomic Energy Agency in Tokai, Ibaraki Prefecture, have devices to clean contaminated water through evaporation. The devices are said to be superior to the French Areva SA system employed at the Fukushima plant.

But Nakamura Hirofumi, who leads the agency's restoration assistance headquarters for the Fukushima plant, said, "Several months are required before the Japanese devices can be introduced at the Fukushima plant. Tepco sought 'ready-made' technology to be used immediately."

A major reason hampering research and development in Japan is the safety myth of nuclear power plants, experts say.

Nakamura said both the state and researchers feel uncomfortable about engaging in research for "military purposes" and "accidents at nuclear plants."

"While the state emphasizes the safety of nuclear plants to nearby residents, it does not encourage research into potential major accidents," he said.

A high-ranking ministry official, who declined to be named, said Tepco's influence in government circles has made it taboo to question its decisions.

"Tokyo Electric Power is too big, and the state is also sensitive to it. Research that Tokyo Electric Power hates can never be promoted."

Japan has implemented some measures to prepare for accidents at nuclear plants. After a 1999 accident in Tokai, the then-named Ministry of International Trade and Industry earmarked ¥3 billion for robotic research and development. Enterprises that participated in the development projects managed to develop six robots in a year and half.

But a panel, including representatives of power companies, that studied the practical use of the robots, concluded that they could not be used "at the present time" because of, among other reasons, their slow operating speeds. The robots were put aside indefinitely.

"They could have been used fully with some improvements. Development itself alone is not good enough. The key is to maintain and carry on technologies, including training users," said Mano Takahisa, deputy head of the investigation and research division at the Manufacturing Science and Technology Center, which took part in the development of the robots.

Other experts noted there is no market for robots that could aid in disaster prevention at nuclear plants because utilities have had no intention of buying them from the get-go.

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