On April 19 and 20, we held the FANUC Open House in the FANUC Headquarters Nature Hall. Due partly to the good weather, the exhibition was bustling with more than 7,000 visitors, far exceeding last year’s total. At this year’s exhibition, we presented our proposals under the following three exhibition themes: FANUC IoT, improved operation rates, and easy-to-use startup packages. The proposals were developed to pursue the ‘one FANUC’ goal initiated last year to integrate production across the diverse product categories of FA machines, robots and robomachines. FANUC’s new products designed to create a non-stop factory system by promoting visualization and automation in customer’s factories attracted many visitors’ attention and was well-received.

In the FIELD system area, programs designed to monitor not only robots but also CNC machines and other peripheral devices and to predict malfunctions and improve operational efficiency at manufacturing sites captured visitors’ attention. Many customers expressed an active interest in using these programs. Visitors were also interested in a demonstration of a bin-picking robot that learns operations in a short period of time using cutting-edge, distributed deep learning technology. The demonstration presented a technology that offers great possibilities for the future. In the area where easy-to-use startup packages for robomachines and robots were exhibited, we received various questions from customers who have been hesitating to use robots for automation due to difficulties involved in creating systems. Our startup packages were evaluated highly for their ease of use. In the FA area, we demonstrated FANUC’s iHMI, which provides great ease of use and new functions, on a special stage as well as in a hands-on experience session to respond to customers’ pressing needs for CNC systems that can be used in factory production.

In the robot area, green collaborative robots, including the new 7-kg payload series, and a laser-welding robot that performs operations using a fiber laser machine captured the attention of many visitors. The robomachine area was also constantly full of visitors who were attracted to demonstrations with a ROBODRILL designed to further enhance performance with quick, efficient movements, a ROBOSHOT whose scope of application has greatly enlarged with its three-material-molding capability, the ROBOCUT series with new large models, and a new ROBONANO model with sub-nano-level processing capability.
In the service area, we displayed machines used in factories to present case studies on how to maintain old machine models, along with useful functions that help improve the operating rate. We introduced visitors to FANUC’s spirit of “Service First” using actual machines in order to help them understand that FANUC products can be used safely anywhere in the world.

### [Key exhibits]

**FANUC’s initiatives in IoT**
- Factory automation (FA)
- Pursuit of increased usability with iHMI
  - Interactive programming function for combined lathes
  - Interface unit for instruments and new measurement functions
- Robust support for introduction of IoT (network for visualization)
  - MT-LINK
- New functions for the 30i and 0i series
  - Upgrades for the 30i /31i /32i-B
  - New smooth tolerance function
- Power Motion i-MODEL A
- Large servo motors from the aiS-B series
- Completed lineups of Model-B servos
  - Fast, precise, and efficient servos from the ai-B series
  - Revamped DiS-B, LiS-B, and Bi-B series lineups
  - Optimal control with a smart machine control system
- Fiber lasers designed for various applications
  - FF3000i-A robots for fast and precise fiber laser cutting
- Robots
  - 35-kg portable collaborative robots and hand guides
  - Small collaborative robots
  - Vibration control of servo guns by learning robots
  - Intelligent arc welding system
  - Genkotsu robot system
  - Visual arc tracking system
  - Machine learning by bin-picking robots
  - Food systems by fully covered robots
  - Painting systems for vehicle panels
  - Super-heavy-weight transportation systems with a large 2.3-t robot
  - Functions to aid considerations for maintenance, safety, and application
- Easy startup packages for robomachines and robots
- Application of IoT to robomachines
  - New ROBODRILL series and robotic processing cells
- Composite molding with ROBOSHOT and robotic precision molding cells
- New ROBOCUT series and robotic processing cells
- New ROBONANO machining models with enhanced usability and operation rate
  - Zero downtime, ROBOGUIDE
  - ROBODRILL-LINKi/ROBOSHOT-LINKi/ROBOCUT-LINKi

**FIELD systems**
- Processing time prediction function
- PANELi for wide LCDs
- I/O unit compatible with IP67
- High-precision program commands
- New processing condition selection function
- Fast, highly responsive, and multi-axial synchronous control of industrial machines
- Helps transition to motor-driven and power-saving industrial machines
- Enhanced the specifications of 400-V βi-B series servos
- Selection of optimal servos with a servo sizer
- Fiber laser welding robot system
- CR-35iA, hand guides
- CR-4iA, CR-7iA, CR-7iA/L
- R-2000iC/270F
- ARC Mate 100iD
- M-1iA, M-2iA
- LR Mate 200iD
- M-20iA/35M, M-20iB/25
- M-25iC/25C
- P-250iB
- M-2000iA/2300

**Zero downtime, ROBOGUIDE**
- ROBODRILL α -DiB series + FANUC robot
- ROBOSHOT α -SiA series + FANUC robot
- ROBOCUT α -CiB series + FANUC robot
- ROBONANO α -NMiA
On April 25 (Monday), we invited university researchers who provide us with continued support to the Open House and held a round-table talk afterward.

**Attendees**

- Toshiro Higuchi Professor Emeritus of the University of Tokyo
- Yoichi Hori Professor of the University of Tokyo
- Hidenori Shinno Professor of the Tokyo Institute of Technology
- Hideki Aoyama Professor of Keio University
- Atsushi Matsubara Professor of Kyoto University
- Takashi Matsumura Professor of Tokyo Denki University
- Shigetaka Takagi Professor of the Tokyo Institute of Technology
- Keiichi Shirase Professor of Kobe University
- Hiroyuki Sasahara Professor of Tokyo University of Agriculture and Technology
- Masatoshi Ishikawa Professor of the University of Tokyo
- Shigeki Sugano Professor of Waseda University
- Hajime Asama Professor of the University of Tokyo
- Toshiyuki Obikawa Professor of the University of Tokyo
- Tojiro Aoyama Dean of the Faculty of Science and Technology, Keio University
- Hidetoshi Yokoi Professor of the University of Tokyo
- Masanori Kunieda Professor of the University of Tokyo
- Yoshiharu Inaba President and CEO
- Kenji Yamaguchi General Manager, Production Division
- Hiroyuki Uchida General Manager, ROBOMACHINE Business Division
- Kiyonori Inaba General Manager, ROBOT Business Division
- Shunsuke Matsubara General Manager, Research & Development Administration Division
- Hiroshi Noda Vice General Manager, FA Business Division
- Hidehiro Miyajima General Manager, CNC Software Laboratory
- Mitsuyuki Taniguchi General Manager, SERVO Laboratory
- Yuji Nishikawa General Manager, LASER Laboratory
- Kenichiro Abe General Manager, Robot Mechanism Development Laboratory
- Tetsuro Kato General Manager, Robot Software Development Laboratory
- Dong Zheng General Manager, ROBODRILL Laboratory
- Satoshi Takatsugi General Manager, ROBOSHOT Laboratory
- Yuji Takayama General Manager, ROBOCUT Laboratory
- Hong Rongshao General Manager, ROBONANO Research Department
- Masako Sudo Chief Engineer

(Job titles as of April 25)
President: Thank you for visiting our exhibition today. The tour of the Open House was brief, but I believe you were able to enjoy the displays that interest you most. We would be pleased if you could provide us with your candid comments about this year’s exhibition.

Professor Higuchi: The way you approach exhibitions has changed over the past few years, so I was curious to see how products would be displayed in this year’s exhibition. The layout was entirely different from last year. I also noticed that many green robots were displayed this year. My overall impression is that more specific products were displayed in many areas. This year, I also had the impression that individual products have steadily improved in performance. For example, in the area of ultra-precision machining devices, one of my fields of specialization, systems have greatly improved in performance by using hydrostatic pressure for the guidance systems. FANUC is making steady efforts to develop each elemental technology. Also, the exhibition clearly highlighted product reliability, which is advertised at the exhibition every year. Let me also mention something related to the use of computers. It is very important to monitor how systems are actually operating. Of course FANUC has to develop various technologies on its own, but how sensors and other technologies developed by other companies are incorporated into FANUC’s products will become more important than ever in the future. Also, although I sometimes wonder what’s new about Germany’s Industry 4.0 that is being so hotly debated in recent years, technologies that suggest the future of industry are actually being proposed in this exhibition. In that sense also, I think this year’s exhibition was effective in showing what FANUC is working to achieve, not only to experts, but also to the public at large.

President: Thank you. In this year’s exhibition, we placed FA products in the middle to highlight our core technologies and laid out robots and robomachines on both sides of the FA area. We also arranged the displays from the users’ perspective to help visitors easily understand them. We put considerable effort into reviewing what items should be displayed in exhibits, how they should be displayed, what should be explained, and who should give the explanation. Also, while displaying new models and new functions for FA machines, robots and robomachines was certainly important, we also wanted customers to understand our “one FANUC” initiative for the future, which is aimed at providing an easy way to combine different technologies. Therefore, we displayed systems that integrate different categories of products in the middle under the title “one FANUC,” including displays that show how to connect robots and NC machines as well as our Quick Startup Package (QSP) that easily connects robots and robomachines. The FIELD system, which uses IoT technology ahead of the times, is also part of our “one FANUC” initiative and involves all technologies, including FA machines, robots and robomachines. As a manufacturer focused on edge-heavy computing rather than manufacturing execution systems (MES) or upstream cloud computing, FANUC aims to develop IoT systems specialized for manufacturing machines and robots. And by adding deep learning, we exhibited the FIELD system in the middle to highlight our proposed technologies specialized for factory edges, including processing and manufacturing. We also exhibited the HMI user interface in a way very different from past exhibitions. I believe these attempts created a different impression from last year’s exhibition. We would be happy if you could provide us with guidance in these respects as well. Now, may I ask for your comments, Professor Hori?

Professor Hori: I also had the impression that this year’s exhibition was easier to understand than last year’s. As you probably know, university classes are also becoming easier to understand. Nowadays, we even provide students with advice about which courses to take to study a topic. In the old days, professors gave lectures in their own ways and students were expected to piece it together for themselves. Today, we need to guide them every step of the way and follow the policy of providing easy-to-understand lectures. I’ve heard similar comments from automobile manufacturers. Such transparency is of course important and wrongdoings have come to be punished rather quickly—although I sometimes feel that we have left ourselves no breathing room. At any rate, today’s circumstances lead me to believe that it is necessary to make things easier to understand. FANUC’s servo technology, which is related to my field of specialization, is among the most advanced in the world, but that is not enough today. FANUC may also have to become “softer” in the future, which is kind of unfortunate. But I guess things are probably better this way. I saw the servo displays and realized that encoders have greatly improved. I was working to develop sensor-less servo systems, but now I’m starting to think using encoders might be better. And I was also a little surprised to see silicon carbide (SiC) being used in many products. Currently, I am also engaged in developing such devices in a Cabinet Office-related project. As a matter of fact, there is not much demand for SiC in robot-related markets. At least, not like there is in markets related to power systems, automobiles and steel, and especially in motor inverter-related markets. Today I asked whether there is a strong incentive to using SiC and I received a convincing explanation. We will probably end up using SiC in robot-related markets as well.

President: As Professor Hori has pointed out, people may have had the impression of FANUC as a company closed to the public. That’s because we were unable to provide public access to information on our interfaces in consideration of safety and other issues. In the future, we believe it will be necessary to provide greater access to information while simultaneously ensuring safety. Even then, there will be risks for users, so we will need to focus on ensuring safety.

Professor Shinno: As is the case with everything, presentation is vitally important. Our Precision and Intelligence Laboratory is a research institute with a history of 76 years since its founding. However, based on our university president’s opinion that teaching and research on “precision engineering” does not make clear what the institute aims to achieve or what research it is engaged in,
we have been working to reform our institute over the past two years. As a result, we integrated multiple laboratories and research centers into the Laboratory for Future Interdisciplinary Research of Science and Technology, the largest laboratory on our university campus committed to open resources. The laboratory is also realizing its goal of research for social applications by merging different research areas. It has been pointed out that young people these days are not interested in working in the machining industry. However, I personally believe that there is a need to reconsider how machining devices are presented. Today, I took a tour of the Open House site and was strongly impressed with FANUC’s efforts to present initiatives meeting the industry’s needs even more effectively than in past exhibitions. While seeing the new products, I also felt the importance of discovering new things by learning lessons from the past. Next-generation production systems were hotly debated during the 1980s and 1990s. This exhibition gave me the impression that key technologies discussed in these decades, including all elemental technologies required for self-diagnosis and self-repair, have now become available. In addition to conventional sensors, actuators and controllers, big data and AI technologies are available as elemental technologies for self-diagnosis. That is why I have no doubt that self-diagnosis systems will realize themselves in the future. I think FANUC is now focused on developing self-repair systems. In next year’s new product exhibition, such products may actually be displayed. In the future, in order to find new challenges for research and development, we will need to go back to the starting point and re-examine peripheral technologies based on research papers published during the time when production systems and FA were hotly debated. Technologies required for intelligent spindles, which were first proposed a long time ago, will be developed in the near future. Self-tuning technologies are also not far from being completed, considering the high resolution of the Pulsecoder and the progress in the use of intelligent control technologies. For these reasons, I felt that it was important to review research themes once again for the purpose of discovering new things by learning lessons from the past.

President: Thank you very much. As Professor Shinno mentioned, most of the technologies were already available in the IMS project that started in 1987. At that time, however, there was no Internet and AI technology was not as well developed as it is today. That is why the project was abandoned unfinished. Now that technologies have matured, we think that going back to the starting point and implementing the project once again may greatly contribute to improving production systems. FANUC will continue to take an active part in making proposals.

Professor Aoyama (H): In your presentation last year, you mentioned “Predictable” as one of the three key design features you are pursuing. Remarkably, some such features have already been incorporated in the FIELD system you presented today. I am most curious to see how FANUC will shift from its past approach to take a more open stance with its technologies. The FIELD system is probably still in the prototype phase but I am interested to see how the concept will be fleshed out. If I remember correctly, there was a newspaper article that said “FANUC jointly developing IoT with Western partners.” IoT was still in its infancy when I saw your exhibition last year. Today, I already see some progress through tangible systems making use of the technology. Among cloud, fog, and edge, intensive efforts are visible in edge computing as FANUC’s core competency.

By the way, last December, I had the chance to visit a manufacturing plant in Taiwan. Among rows of 20 to 30 machines, I spotted two ROBODRILLs made by FANUC. The plant has a policy of checking their precision every morning, noon, and evening. They told me that the precision is least compromised with ROBODRILL and the processing speed is twice as fast as other machines, which proved to me the effectiveness of ROBODRILL in parts processing. As they put it, “a 5-axis ROBODRILL machine is used for parts processing as the machine is faster and works more precisely than other multi-spindle machines.”

Back on topic, each of the specific technologies I saw in the tour today was quite interesting, including various features of “Reliable”, “Predictable”, and “Easy to Repair”. The second feature was demonstrated in the FIELD system and ZDT function in today’s exhibition. We are advancing in the very direction you suggested. We look forward to your continued guidance as we try to enable the FIELD system to handle an integrated flow of data starting from CAD.

Professor Matsubara: The application of IoT was clearly demonstrated in today’s exhibition. Recently, I participated in a workshop with IoT specialists from Nomura Research Institute and professors from departments of information science. They told me that IoT is like a neural net, and that AI is actually more important. That made sense. In this analogy, the FIELD system is the neural net of IoT and AI is the software developed on the net, which will make the real difference over other systems. The world of cloud computing is underpinned completely by open resources. In other words, the software (which plays similar roles as in the parts of a machine) is free. This world attracts many kinds of talents. But safety is not guaranteed there. So, I suppose the world of FA requires a different design model. This makes me wonder whether the design process should involve third parties or a team of different talents. My impression from the exchange with specialists in the world of cloud computing is that they are free thinkers and they enjoy what they do. I do think their style is quite crucial and the world of FA should also pick up on this idea of developing something new just because it is fun.

President: The FIELD system is open for third parties to contribute their content. The FIELD system platform accepts content developed by system integrators with diverse talents for customers to use. Presently, about 100 companies have declared their bids to work with us this
way. Once these partner companies produce more and more content, our assets will pile up enormously. This probably marks a new era where programs for service life management of tools and optimal processing conditions can be freely chosen just like we download whatever app we want on our smartphones. In this sense, the FIELD system is an open architecture, which is expected to develop further.

Professor Matsumura: Like in the example of the FIELD system, an increasingly open system will lead to diversification of usage, which will then prompt the development of various kinds of applications. Accordingly, your company will probably experience greater workload in providing support to application users and system integrators.

Large companies will waste no time in introducing the FIELD system as it is so advanced and offers attractive and innovative solutions. Increasing openness of the system will require other companies that partner with these large companies to share information and applications. The benefits from the introduction of this system will probably depend on how effectively smaller companies can use the system and how the underpinning concept can take wider root. In that respect, I have been interested in training, support, and introduction programs for smaller businesses. I also believe the life line of the FIELD system lies at the fog level. What I especially appreciate is the compatibility with older machines. This is good news for smaller businesses that cannot invest in new equipment. Applications for the latest operating systems and functional upgrades can be used with a controller. In this regard, adequate consideration has been given to upgrading the functionality of the equipment of smaller businesses. I personally have felt that the FIELD system can reinforce the foundation of Japanese manufacturing industries provided that many smaller companies appreciate the system.

President: I agree with you completely. The system introduction will naturally take place among parent companies. But we believe the application will expand quickly to their Tier 1 and Tier 2 suppliers to provide a powerful system, a powerful server is usually installed to operate the FIELD system. For small- and medium-sized companies, our relatively small hardware called FIELD base may prove to be an approachable way to establish FIELD systems. How long will it take for the system to take root? Time will tell, but I think this year marks the very beginning. Big data can be obtained from the introduction of the system among many users, which helps us to develop more sophisticated functions. We are currently discussing what kind of data is processed in what way in a manufacturing process for what kind of use. We will try to lower the hurdle for introduction by avoiding high prices. We appreciate any advice to toward this end.

Professor Takagi: I also found the FIELD system interesting. I used to wonder what a network connecting different robots would be able to achieve. During the exhibition, I was able to see how the faster data sharing and learning would be great advantages. My impression is that this approach can be regarded as Japanese Industry 4.0 rather than German Industry 4.0. The key to success in your ambition to make a portable collaborative robot weighing over 35 kg out of the model that won the award will be the way you cope with noise problems. You said FANUC uses AD converters with a resolution of 15-16 bits. However, AD converters with 32-bit resolution are already commercially available. Simply increasing the bit resolution is easy, but the real challenge is the noise. Noise simulation technologies have advanced to the place where they can simulate boards of around 30 cm, a stray device from an IC packaging, and an IC inside the IC package all at the same time at a precision level down to tens of nanometers. This advancement has enabled both macro- and micro-analysis from various perspectives. Noise can also be visualized to demonstrate that noise appears in completely different ways depending on how a device is grounded. Such visualization is the first countermeasure against noise. In my opinion, it is important to first identify sources and causes of noise. Another approach is multiplexing. Although multiplexing has already been put into practice to channel signals through more than one route, based on my research, tweaking the multiplexing method can probably improve the performance of your products to some extent. Lastly, how about considering low frequency noise cancellation? For instance, BOSE headphones are used in aircraft and so forth. The idea may work if the noise cancelling frequency is sufficiently low.

President: Thank you. As you rightly pointed out, we are aware of the need for robots weighing 70, 80, or 120 kg although we started developing robots weighing 4 kg and 7 kg to meet the greater market demand. Like you, we also believe that noise poses a major challenge as the technical hurdles rise. Once we reach a certain milestone, we would like to try enlarging our robots. We will be seeking your advice as the time approaches.

Professor Shirase: Keeping in mind my visit last year, I get the impression that your pursuit of your three pillars of design, as mentioned earlier, has advanced quite a bit. The newly released FIELD system showcases decisive openness of your CNC units and robots. Although I didn’t have a chance to listen to the details, I learned that a digital servo adapter can be employed to give orders directly to a servo amplifier from EtherCAT (made in Europe) or another external network. This gave me the distinct impression that your company has made a decisive turn toward open source hardware as well as software. Unfortunately, I was unable to see how your products collaborate with software from another company. But I look forward to seeing this soon, as IMTS and JIMTOF will be held this year. Servo data can be retrieved with your servo viewer and SERVO GUIDE, but their real-time performance for feedback control is still not guaranteed. General users may not expect that much. Still, I would expect FANUC to try to enable serious users to use servo data and sensor signals for feedback control. I am not very clear on how hardware and software are linked in your system. It simply improved the real-time feedback of data from subordinate hardware to superordinate software would be difficult in a hierarchized network.
Further pursuit of a smarter machine would probably require a separate interface for real-time connection of software and hardware. For instance, sensor signals are presently processed through deep learning. A more intelligent process would increase the need for real-time comparison of new and old sensor data to make smart judgments or diagnoses. I am convinced that the need for more effective use of raw data from work sites in software will emerge to press us beyond mere connection of software via a hierarchical network.

In relation to Industry 4.0, some say it is all the same idea from 20 years ago. However, the necessary skills and knowhow have not yet been addressed to the point where the idea can be turned into reality. Honestly, we are also struggling with how to address these issues. Deep learning basically means “I don’t know what this signal means, but I’ll process it and make it so it can be used as an instruction.” When it comes to skills and knowhow, it is unclear what kind of data needs to be collected and how it should be analyzed or processed. The public thinks that deep learning is a tool for beating chess masters. They think it can be used to solve any problem. My concern is that the current framework is not conducive for learning skills and knowhow. We study what kind of data needs to be analyzed and processed in what manner for learning purposes and knowhow. We are also interested in the process of observing how FANUC will open up their product designs and how such open designs will relate to our research.

President: Thank you. You are right. Deep learning is not a be-all and end-all, though it certainly is a technology with enormous potential. We use feedback from machine sensors for learning purposes. In the future, it will be worth trying an approach that reproduces the skills of skilled workers with deep learning using data from auditory sensors, olfactory sensors, and machine vision. We would also like to try this with issues that we face in the future. The technology has a lot of potential. Even starting with just steadily addressing immediate challenges, IMTS is expected to offer various ways of making improvements. As I mentioned earlier, the FIELD system is open. We are also thinking of asking third parties to contribute content and to form tie ups with products made by our competitors. There are few manufacturing plants that operate exclusively with control units from FANUC. Normal manufacturing plants employ both new and old equipment and manufacture products made by our competitors. We will develop our system to be of use in such manufacturing plants. We look forward to your guidance in this regard.

Professor Sasahara: I am participating in this event for the first time. As other professors have already mentioned, cloud computing by the FIELD system and your latest initiatives to make the most of IoT have intrigued me as well. From a slightly different perspective, I was also interested in complex processing. Your company has developed a FIBER LASER with a large output up to 6 kW, which demonstrated cutting and welding of a fine thin plate. In addition to the tiny pitch processing, I was impressed that your brochure talked about your plan to introduce at a higher level of the system cannot operate anything without sufficient input data. So, sensors for taking data should be more densely deployed and they need to be diversified. Greater performance can be expected, as mentioned by the president earlier, when
other types of sensors are incorporated without a cost increase followed by a process involving artificial intelligence or the like. Many of the sensors you presented today were quite remarkable. And I am sure there will be more to follow. Not to mention visual and three-dimensional sensors, active use of proximity sensors, auditory sensors, and so forth can also harness the power of IoT when the higher density is pursued both in terms of time and space.

**President:** Thank you. You have rightly pointed out that we should distinguish “integration” and “fusion” with great care. We would like to come up with something new by means of fusion. We will try to develop active and adaptive performance, as well as associated functions by obtaining diverse data from various sensors while minimizing the cost. I guess that process can be called fusion.

**Professor Ishikawa:** Yes. Ideally, such fusion should provide a new function.

**President:** Indeed. Thank you for your continued support.

**Professor Sugano:** Every year, your green robots draw my attention, as I specialize in human symbiotic robots. It is very nice to see more kinds of such robots. In the recent robot exhibition in the Big Sight, I found collaboration robots by FANUC to be more advanced than those produced by other companies. I believe the advances will accelerate. Collaboration has become a buzzword in many areas. New projects to pursue collaboration between robots and humans have gotten underway. The future relationship between humans and robots is often discussed when I myself consult with NEDO and private companies regarding possible partnerships. My impression is that not much progress has been made from the minimum level of ensuring safety, and so on. It seems there is a deep rooted belief that humans and robots can never touch or bump one another. Our laboratory is conducting research based on the assumption that we don’t mind if robots bump into us. This approach triggers a rejection reaction in many people. Bearing that in mind, I would like green robots to go beyond static contact between humans and robots toward more dynamic collaborative movements. We hear a lot about robots that cooperate with humans in medicine and nursing. But I believe industries and manufacturing plants offer a greater frontier for human-collaborative robots. In that sense, I believe FANUC can make a huge impact by demonstrating at production sites that your green robots can go beyond simply stopping safely to continue moving even after making human contact, and then take the bolder step of continuing to work after bumping into humans. I would like you to press ahead in developing such a technology.

**President:** Thank you. That’s quite a challenge. It’s not a big issue when a worker bumps into another worker. If robots are involved, such contact is considered dangerous. If we build up enough evidence to prove that slight contact with robots is harmless, then the way people think may gradually change. In order for this to happen, we must develop fundamentally safe robots by dealing with the many challenges ahead. We will seek your advice toward that end.

**Professor Asama:** Today I noticed new steps taken by FANUC. Your green and white robots showcased the progress. In terms of collaboration with humans, I also noticed a bold step as pointed out by Professor Sugano. The application of relevant technologies like deep learning and artificial intelligence for controlling and maintaining machines struck me as innovative. FANUC also impressed me by taking up the challenge of opening the network of the FIELD system. Japan is seeing various types of investment projects in the robot industry, ones that will propel us forward. In particular, the industrial robots you presented today should still have substantial room for growth. I became intrigued to see how the business can be developed to exploit the potential, and how new services can evolve out of the junctions between the service and manufacturing industries.

Let me share my impressions from today. The first is related to the reduction of human workloads by collaborative robots in safe and efficient production. I get the impression that FANUC is becoming capable of simultaneous simulation of the movements of robots and humans. Two types of workloads need to be reduced. The first is physical workload. For instance, in the nursing industry, tasks involving lifting over are about to be totally banned because the resulting back pain is responsible for higher turnover. The measure helps create a more worker-friendly environment. Another type is mental workload. Construction machinery manufacturers are advancing their research. The evaluation of the resulting degree of fatigue after long hours of operation is significant. The Delight Design of SIP led by Professor Hiromasa Suzuki also evaluates the value of products not only in terms of their performance, but also the degree of delight they deliver. Rather than simply switching to automation with robots, I felt there is much room for improvement in reducing human workloads and enhancing the level of comfort in a system that collaborates with humans.

My second impression is related to the FIELD system that took up the new challenge of pursuing a bottom-up approach as opposed to the concept of Industry 4.0. A network can be opened up on two frontiers. The first one is systematization. In the Robot Award two years ago, a system that handles the logistics of drugs entirely with robots won the award for excellence. The achievement was highly evaluated for the overhaul of the logistics system, rather than partial adoption of robots. But I believe this can be achieved easily by adopting the concept of the FIELD system. Greater application of the FIELD system can be expected for such systematization. The second frontier is maintenance. Product service systems (PSS) are becoming the mainstream in service industries. In addition to simple sales of products, these systems seek to exploit business opportunities in maintenance during their use, which naturally experience deterioration and failures. The FIELD system helps us to run a business while users are already using products. I believe deep learning of failure data will lead us to more reliable manufacturing.

**President:** Thank you. We would like to exploit that potential. If industrial robots evolve enough to make human workers want to work with them, this will produce a more conducive working environment for humans. We would like to be part of that advances. Our first green robot in our manufacturing plant works in a space shared with a female worker. Heavy physical work with a
component weighing 19 kg is performed by the green robot. The assembly requiring more skills is performed by the female worker who guides the green robot. It is quite an interesting collaborative operation. We feel that robots need to be even smarter and more dexterous so that humans can enjoy collaboration with them.

Professor Asama: In that respect, robots made by FANUC may prove effective for nursing. Despite the common reputation of Japan as a robot powerhouse, Japan lags behind in the application of robots in nursing. There is great demand for collaborative robots that spare humans from toiling with heavy weights, and this offers a great opportunity for green collaborative robots to shine.

President: Thank you.

Professor Obikawa: The new ROBODRILL you showed us today really impressed me. Now that your ROBODRILL has a new cast for skeletal remodeling, I guess it is getting ready to move on to the next stage. More specifically, wasted cutting time can be significantly reduced with smooth operation by reducing internal interference and adding a servo function to the tool changer. In my eyes, the machine is pioneering the next era. The load meter for the main shaft was quite intriguing. The machine can handle over 600% of its rated output for a short time, which is expected to expand the scope of applicable processes. The indication colors of the load meter changing according to the number of revolutions and duration of continuous machining are a quite original and helpful way to check the status. It struck me as a new way to use machine tools.

In my opinion, customers would feel even better if you enable the automatic setting of a tool path and machining conditions in the process of creating actual NC cords from CAM. The machine has been refined with advanced functions also in terms of the hardware. Since the FIELD system adopts an open architecture, I am interested in the countries where the system will be used the most. Japanese tend to lag behind in creating new software, compared to the rest of the world. I get the feeling that applications for FANUC will be used most often and new proposals will be made outside Japan. This is actually not a problem. New ways of using new machining tools and systems can be proposed in any country. And I feel that such new uses are evolving at an accelerating pace.

President: Thank you. Actual machining does not involve continuous rating of spindle load under human adjustment with visual observation of the load meter. The smart load meter will prove quite useful as sufficiently advanced cutting conditions can be set for machining with a small spindle motor. The FIELD system can usher in a world where adjustments can be made automatically. I look forward to an automatic adjustment function supported by AI to pursue the limit of performance in response to overriding adjustments by human operators. I also hope that third parties will emerge to take up the challenge in the countries where the system will mainly be Japanese. But I believe American and European counterparts can develop content that suit local styles. As for the servo turret, the previous ROBODRILL was driven by the spindle motor for the main spindle for better cost performance. The turret’s movement was as smooth and fast as could be. In order to further upgrade the performance, the new model employed a servo motor. We will continue to pursue even better performance.

Professor Aoyama (T): I spent most of my time learning about your ROBONANO. It was a wise decision to introduce a hydrostatic guide. I’m sure the excellent performance owes to advanced manufacturing technologies that support the theory built upon past efforts. Setup and tooling time for machining seem to have been reduced. An astounding era may be on the horizon, where robots perform setup and tooling for nano-machining.

Following up on the discussion of the FIELD system, I remember the time when I was jointly developing the system with FANUC in the IMS project. The last stumbling block was what corresponds to edge computing in the current FIELD system. The performance at that time could not achieve tasks in an ideal manner.

Listening to your presentation of the today’s FIELD system, the on-site application is quite clear. Of course, IoT and sensor technologies play core roles to achieve this, which in turn requires robust edge computing. I felt that serious efforts must be made to improve the edge computing performance and not only for ROBONANO. I noticed many changes in today’s exhibition, including your efforts to bring various disciplines together. For instance, FANUC’s deep learning employs information science. Maybe it is an exaggeration to call it an integration of art and science, but certainly your company is moving in a new direction.

You mention that cloud computing is not one of FANUC’s goals. Still, it may be a good strategy for your business to keep track of products being produced with your machines in Japan and the rest of the world and what kind of response is necessary to address any problems. The obtained data should be judged whether it can contribute to society, whether it contributes to your business, and whether users are experiencing any disadvantages with the system.

President: Thank you. We especially appreciate your earlier advice for making a hydrostatic guide for ROBONANO. As for the FIELD system, we mainly focus on edge computing. Among our current alliance partners, Rockwell Automation and Cisco Systems have competence in cloud computing above the level of MES. So, we do not directly deal with the cloud. That said, we do have experience in preventing line stops through zero downtime (ZDT) as a function to provide customer services using information from cloud computing. Also, data is processed through the cloud for conducting operations across different manufacturing plants. Large-scale users, however, have already established MES or other systems for such manufacturing plants. We take charge of on-site needs by means of underlying fog computing in order to ensure easy fusion with superordinate systems. We are trying to ensure that the FIELD system that handles edge computing can deliver necessary functions even when the superordinate system is Industry 4.0 or ISE.

ROBONANO, among other FANUC products, will continue to pursue unbreakable design, preemptive warnings of...
breakdowns, and quick repair of breakdowns. Thank you in advance for your continued advice.

Professor Yokoi: To begin with, congratulations on your delivery of 50,000 units of ROBOSHOT. That’s quite an achievement. I remember your products from the AUTOSHOT series. It is already a throwback. What surprised me first in today’s exhibition was this sample molded with three materials. Honestly, I was impressed that FANUC had come this far. FANUC completely mastered the underlying technologies for making molding machines and has ever since delivered excellent molding machines as individual units. In response to the latest trend in composite materials and intra-mold monolithic molding, I used to think that molding machines made by FANUC with robots cannot meet such specific demands. But, now I see your company has the capacity to develop a system that can respond to diverse needs in a fine-tuned manner. A simple package combining your ROBOSHOT and robots, I suppose, is intended to quickly respond to individual requests from customers. The two-color molding process you showed today employed a combination of a molding machine with injection units both in vertical and horizontal directions. On top of that, the molding machine can perform silicone molding which requires two (actually four) kinds of materials. In this sense, an extremely complex work lot is divided into different units to combine them again to quickly meet diverse needs. In addition, your small collaborative robots can automatically correct their position with their cameras even when their position is slightly dislocated during their transport on a wheeled platform. They are developed with ultimate consideration to ease of use by users. So, my first impression is that FANUC has transformed. Regarding the FIELD system, let me mention that injection molding machines do not process materials in direct connection with servo motors. Actually, there are screws and molds between target materials and motors. I cannot fathom what is happening in these molds. Edge computing may not help molding machines work with the FIELD system unless FANUC collaborates with sensor manufacturers to find out what is going on when a certain signal is obtained. But let’s remind ourselves that FANUC was the first to release a molding machine capable of actually measuring the internal condition by using a servo motor. Such measurement was made possible by making a reverse flow meter observe materials flowing back from a check valve by using a servo motor. Likewise, FANUC is already capable of freely mobilizing servo motors as sensors. I am hopeful that, once this ability is exploited, we will be able to discover the meanings of signals that we once failed to notice. With thorough one-to-one analysis, we may even be able to know the condition of the materials inside molding machines, which used to be total black boxes. With great anticipation, I advise you to spare no efforts in connecting molding machines with the system.

There was another thing that made me wonder in today’s exhibition. Earlier, you mentioned that FANUC does not disclose its core technologies. Yet, for instance, you are working on core technologies that support the core part of screws and what your company is mainly displaying technologies supporting interfaces with users without presenting its core technologies. Anyway, what really matters and what makes the last difference is the core technologies. Manufacturers like us need to continue to underpin the development of machining technologies. Advancement can be made through pursuit of differentiation. I would expect you to seek further development of such core technologies. Recently, various methods are being proposed for integrating carbon fibers, glass fibers, and other fibers in a molding process. FANUC certainly must be working on these technologies. There must be many challenges to address including the basic steps to mold without breaking fibers. My wish is for you to thoroughly unravel the secret art. We are trying to do the same, but it sometimes seems like alchemy.

Professor Kunieda: In an international conference on electrical machining last week, I had the opportunity to listen to a presentation by Professor Klocke from RWTH Aachen University regarding digitized manufacturing and network production. Under conventional models, edge computing and building blocks were simply put aside as black boxes. According to the professor, each block can evolve further as the modeling methods advance in the future, which include chemical and physical blocks. In my student years, I remember I was very disappointed as these blocks were established as black boxes. Models back then left no room for improvements in electrical discharge machining and other processes in which I specialized. Professor Klocke made us aware that there is much room for improvement in each of these blocks. The number of presentations of simulation results is notably on the rise. Neglected for some time, basic research seems to be gathering pace. I am glad to see this positive trend. Actually, I noticed the word “edge-heavy” in today’s exhibition. I asked Mr. Takayama what the intended meaning was, and he told me it is to “place emphasis on edge computing.” From that word, I get a glimpse of FANUC’s efforts to understand the basics of machining. Quite often, accepted myths prove mistaken in the study of electrical discharge. Even if one tries to point out these mistakes, it is extremely hard to defy what everyone considers common knowledge. People tend to conveniently explain any future results with established myths. That is all the more reason why I believe breakthroughs can be reached when you place a premium on basic research that can overturn conventional wisdom or established myths.

President: Professor Kunieda has been providing us with advice on wire cutting (ROBOCUT). Many things remain unknown about the complex behavior involved in wire cutting. We are counting on his continued guidance. We began to realize that deep learning could significantly help us to discover secrets in this field. ROBOCUT as a wire cutter works with a considerably large number of parameters, which makes it difficult to systematize the control theory. We strive to develop a control technology with solid theoretical foundation by applying technologies from machine learning. This concludes the meeting. Thank you very much for your participation.
Our robot factory handles both assembly and testing of robots, and it has a production capacity of 5,000 robots every month. FANUC produces most of the key components for robots in-house. CNC units from our CNC factory, servo motors and servo amplifiers from our servo factory, cabinets from our Sheet Metal factory, and mechanical parts produced in our machining factory are brought together at the robot factory for assembly. Self-manufacturing of key components ensures high quality and reliability.

The operation of the robot factory is automated, which means robots assemble the new robots. Automated assembly systems of multi-purpose intelligent robots from the R-2000i series consist of many assembly cells where each unit of robot is assembled. These units are combined into upper arms and lower arms, then ultimately coupled into the new robots. FANUC’s vision sensor iRVision and force sensor are effectively employed to enable robots to perform assembly operations that human workers relied on their eyes and sense of touch to do.
For the three days from March 16 to 18, the FANUC Global Conference (FG Conference) was held with the attendance of FANUC Group employee representatives from across the world to discuss future product development and sales strategies.

Following last year, participants had a lively discussion under the three slogans, “one FANUC”, “Service First” and “Reliable, Predictable, Easy to Repair”

At the conference this year, participants renewed their commitment to revolutionizing factory manufacturing worldwide with the FIELD system released in April, deep learning technology, and by expanding laboratories.

When the conference schedule was completed, a party was held under the auspices of the President and all participants deepened their friendship.
This year, FANUC was awarded the 2015 FT ArcelorMittal BOLDNESS IN BUSINESS AWARDS Drivers of Change Award from the Financial Times and ArcelorMittal.

The BOLDNESS IN BUSINESS AWARDS are awarded to companies with vision and leadership that make bold and creative decisions to take risks. The Drivers of Change Award, above all, is known as an award granted to innovators who are not afraid of changing their companies or even their industries in their entirety.

Apple and Amazon have also won the Drivers of Change Award, which has been awarded eight times. At the awards ceremony, held March 17, 2016 at the Royal Institute of British Architect in London, a commemorative trophy and a certificate of award were handed to Senior Executive Vice President Gonda, who attended the ceremony on behalf of President Inaba.

On June 1 this year, a factory completion ceremony was held at the Mibu Factory, the second most important manufacturing site for FANUC’s FA business next to the head office factory.

A barrel containing local sake brewed in Tochigi Prefecture was opened to celebrate the completion of the factory with many guests in attendance, including Tochigi Prefecture Governor Tomikazu Fukuda and Mibu-cho Town Mayor Kazuya Kosuge.

Overview of the Mibu factory
Plants: electronics plant, servo motor plant, molding plant and shipment center
Total floor area: approx. 254,000㎡
Initiation Ceremony

An initiation ceremony was held on April 1 to welcome 221 employees as new FANUC members. Hearing the encouraging message of President Inaba (currently Chairman), the new employees renewed their commitment.

Message of the President (currently Chairman) (Excerpt):
New employees, congratulations on joining FANUC.
Since its foundation, FANUC has been engaged in business activities focusing on automation and robotization in the manufacturing industry. FANUC is the world’s top manufacturer in this area and it is our highest priority to maintain this position.
I believe you all joined our company with dreams of a brilliant future. At present, however, the world economy is going into a recession. In other words, you are embarking on a voyage in a storm. You must be prepared for a recession that will last several years at least. However, viewed from a different perspective, you may consider yourselves to be lucky.
That is because you can experience first-hand what you need to do to maintain the existence of the company in an economic recession and your experience is bound to be useful in the future. Also, to maintain the existence of the company, it is necessary to take up challenges. At FANUC, we are implementing challenging strategies in all divisions in order to prepare for the economic recession. No matter where you may be assigned, you will have mountains of work to do.
You are expected to take the initiative to open the door to a bright future for FANUC. FANUC has always moved forward without looking back. Let’s continue to move on toward the future.
Starting today, let us take strong steps together in the spirit of moving forward and never stopping.
I look forward to seeing you continue to take up challenges in the divisions you are assigned to in order to achieve significant growth and to play an active part as members of FANUC.

Hibiki Mori, the second son of Mr. Mori, Manager, Laser Processing and Turbo Blower Development Dept, Laser Laboratory, FA Business Division, won the award for the best work (Minister of Education, Culture, Sports, Science and Technology Award) in an elementary school newspaper competition. Hibiki Mori had won an excellent work award for two years running in the same competition since he was in the fourth grade. This year, the article he wrote in his final grade of elementary school was chosen from among 6,084 articles for the Best Work Award.
To write his article, Hibiki frequently visited stations along the Fuji Express Railway to conduct interviews with station staff, passengers, travel agents, and volunteer interpreters. His newspaper article impressed even professional journalists. In his postscript, he wrote about his dream of working in an occupation related to railways.

Award Competition

Sponsored by: Association of Japanese Private Railways
Name: Ninth “Private Railways and Me” Elementary School Newspaper Competition
Work title: Railway Closest to Mt. Fuji

FANUC Employee’s Son Wins the Award for Best Work in the “Private Railways and Me” Elementary School Newspaper Competition

Right: Hibiki Mori
Left: Award-winning article

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Sasabaginran orchid (Cephalanthera longibracteata)
(Photographed May 20 near the Guest House)
Sasabaginran orchids grow pure white flowers on straight stems. These flowers stand out against the background of the quiet forest.

Fringed iris (Photo taken May 20 near the Guest House)
Fringed iris flowers with beautiful light purple patterns were in full bloom in the shade of a tree on a fresh spring day.

Arctic starflower (Photo taken May 20 near the first machining factory)
Lovely arctic starflowers with their cute little flowers looking up innocently at me.

Four Seasons of FANUC

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