We've come a long way. Back in 1943, we developed Japan’s first bulldozer, which has paved the way for us to become a full-line construction equipment manufacturer today. In April this year, we unveiled the world’s first Machine Control dozer with fully automatic blade control, D61PXi-23, together with a prototype Machine Control hydraulic excavator, PC210LCi-10, at the Bauma 2013 International Trade Fair in Germany.

The built-in 3D automatic blade control of the dozer receives real-time information of the blade position from the GNSS* and controls the blade according to 3D CAD construction data with the coordinates computed from design drawings. Therefore, the operator just needs to move the dozer toward the work target displayed on the monitor panel. The rest of his/her work is done by the dozer itself, automatically and seamlessly, from rough dozing to finish grading, as if it were operated by a veteran operator.

Thanks to the revolutionary, ongoing advancement of ICT and GNSS* technology, our industrial pace-setting dozer also enables our customers to manage their jobsite conditions, such as work progress, as it is equipped with the survey function for earthmoving work. As our customers and we share our respective areas of expertise to "visualize" their jobsite operations based on data transmitted from our Machine Control construction equipment, we believe that in the near future we will be able to innovate and realize ideal jobsite operations, which feature unprecedented safety, productivity and efficiency. We are excited about this first step forward to a promising future of automating construction jobsite operations.

* GNSS: Global Navigation Satellite System is a general term for navigation systems, which are developed by different countries, e.g., GPS by the United States and GLONASS by Russian Republic.
It is said that bulldozers are more difficult to operate than various other construction equipment. While bulldozers are constantly in vibration, with rolls and pitches, operators need to move them at appropriate speeds as they control the heights and angles of the blade. The way they initiate a cut by positioning the blade on earth also affects construction efficiency. When the volume of earth being pushed increases, bulldozers can slip and damage the surface. To avoid overloading, they need to raise the blade and gradually level the ground. They also need to evaluate soil conditions and ground formations, and then engage in a series of complex operations without being able to look at the blade on the surface. Therefore, it is said that it usually takes three years of experience before they feel competent to operate bulldozers.

Machine Control automatically manipulates the blade for the operator. Mainstream Machine Control bulldozers today are not equipped with functions to detect blade load and track slips. Therefore, they can fully demonstrate Machine Control capabilities only in finish grading. In terms of the expected volume of work starting with rough dozing, only 10% to 20% is automated. Our D61EXi/PXi-23 models are equipped with the world’s first full blade control technologies from rough dozing to finish grading. Therefore, operators are required just to move them forward and backward, leaving all other tasks to our machines, such as rough dozing by automatically controlling the blade to avoid track slips, and high-precision finish grading by automatically shifting to this mode when the machines approach the design surface. We have achieved this fully automatic control by becoming able to detect blade load and track slip information. At the same time, by making the GNSS antenna built into the operator cab rooftop, we have eliminated the problems of cutting the cable and damaging the antenna after getting hit by hard objects as well as of daily mounting and dismounting tasks for the antenna.
It was very challenging for us to recreate the blade control performance of veteran operators by applying ICT. When the body of D61 models moves up and down by one degree, the position of their blade edge changes by 70 mm. Veteran operators control the blade appropriately, as they predict coming changes by using their vision and sensing their body movements. We have recreated blade control comparable to that of veteran operators by tuning more than 20 parameters which combined the iMU+ sensor responsible for recognizing body positions and the MS Mechatro Smart Cylinder capable of detecting cylinder strokes. This tuning process alone took us one year, working very closely with our Test Engineering Center to repeat many experiments.

We conducted seeding activities in cooperation with customers for our Machine Control models in the United States, a major market for medium-sized bulldozers. Seeding activities provided valuable opportunities for me to not only refine machine performance but also learn about how our machines are being used by customers from a development engineer’s viewpoint. For example, I had no idea in Japan that medium-sized bulldozers are used on slope construction. The slope was nothing special when I looked at it, but it required extraordinary efforts of all involved in seeding activities to ensure accurate real-time recognition of machine positions and directions by using the 3D GNSS and iMU+ data for perfect sloping work.

Although D61EXi/PXi-23 models are now in commercial production, I think my next task as a development engineer calls for improvement of customers’ jobsites in the entire construction process, from preconstruction to final survey upon completion. We must improve not only the performance of one bulldozer but also customers’ productivity as a whole. In this way, we will be able to make significant contributions to them. I am now looking into this possibility.
The Hydraulic Equipment Technical Center plays an indispensable role in Komatsu’s commitment to in-house development and production of key components, and I feel that our Center has a particularly strong climate of creating things by ourselves, if we cannot find them available anywhere. One such example is our original MS (Mechatro Smart) Cylinder, featuring in-house developed sensors, which incorporates our electric control technologies, that have been accumulated over 20 years, and our sensor technologies that have been refined over about 10 years for hydraulic equipment. As MS cylinders are installed in construction machines, they are expected to generate big power under rough conditions. Furthermore, there are about 10 meters separating the base of their boom and their bucket, but they are required to move the bucket precisely, calling for the need for smaller than millimeter, super-precision measurement of cylinder strokes.

Before we began development, we first decided that we would never damage the durability and reliability of cylinders, which were proven over the years, by adopting sensors. We also wanted trouble-free applications to other models in the future. To this end, we decided to develop add-on sensors from the very start, without changing the basic structure of cylinders. Development of novel sensors definitely brought about continuous challenges to us.

For example, when you install a piece of magnet inside the cylinder tube made of steel which shuts out magnetism, and install a magnetism-detecting sensor, theoretically speaking, it’s totally impractical. Encouraged by our supervisor, saying "Everything we have in this world has been made by those who truly believed they could make it. When you think you can’t, you just can’t", we repeated the production and simulation of trial sensors. One day, we discovered that we were able to detect a very small amount of magnetism which came through the steel tube, when certain conditions and shape were met.
Although we were able to detect magnetism, it turned out to be useless due to poor measurement. We faced a continuous series of new challenges, such as the fact that magnetism doesn’t travel at the speed of light within magnetized material and the need to consider and evaluate even slight delays caused by very weak electricity generated within magnetized material.

In addition to developing technologies to make sensors more compact and higher in precision, we also needed to plan and develop original bench test equipment for cylinders by considering all possible conditions of machine use, and calibration, inspection and other equipment for mass production of sensors. It has taken 10 years of dedicated effort from more than 20 engineers on a cumulative basis, who were committed to components of ever higher performance and precision.

I would like to develop this model together with customers, as each and every one of us at Komatsu fully demonstrates individual talents and teams up, which is our corporate climate.

Kiwa Nishimura
Chief Engineer, Hydraulic Excavator Development Group, Construction Equipment Technical Center 1, Development Division

Today, we are involved in the development of the second model of Komatsu’s ICT-intensive equipment, i.e., a hydraulic excavator with Machine Guidance functions. Compared to other construction equipment, hydraulic excavators perform complicated movements. For that reason alone, automation is very challenging, so we have decided to launch this model initially, in which operators are required to operate manually but which offers information needed for their operation. This model is in the final test stage, which assumes actual jobsite operations, and is just around the corner for commercial production.
Unlike the conventional development of mechanism-oriented products, the development of ICT-intensive products called for more orientation on applications, which meant designing the monitor in consideration of how the machine is going to be used. Our development project began in 2009 by getting not only development and production people involved, but also product support people who are very familiar with how the machine is used by customers as well as people of ICT device makers at start-up. It was a challenge by one group of people with different expertise. It was also the first experience for me to collaborate with people routinely working at different sites in Japan and abroad, and I have reconfirmed the importance of sharing information and communications.

Komatsu demonstrated a pilot model of the Machine Control hydraulic excavator with fully automatic excavation functions at the Bauma trade fair in April 2003.
Reference: While the operator kept his hand away from the lever, the bucket was automatically moving to shape the design surface.
The adaptation of Machine Control technology is becoming a very important agenda topic of the construction industry today. Along with Australia and Europe, North America is marked by high installation rates of Machine Control technology on customer’s machines. With Komatsu’s announcement of the world’s first intelligent Machine Control dozer in April 2013, the D61PXi/EXi-23, we were well prepared to introduce the next generation of Machine Control technology for improved customer efficiency and operational benefits. Key to the success of the intelligent Machine Control technology was the incorporation of customer feedback and prompt evaluation early on in the development phase by way of user seeding activities in North America during 2011 and 2012.

Partnering for the future

User seeding activities for our intelligent Machine Control dozers consisted of placing pre-production machines in the hands of actual end users on various jobsites. Overseen by Komatsu America Corp., a U.S. subsidiary of Komatsu Ltd, the jobsites ranged across a wide region of North America. Using the final phase of these activities in 2012 as an example, three different contractors with prior machine control expert experience operated a pre-production D61PXi-23 dozer for two weeks each. Approximately 200 hours of customer operation time by six different operators were logged on jobsites ranging from residential site preparation to large road works to environmental & landfill development. Participating customers were selected based on their high level of prior machine control experience, their ability to place the machine in demanding applications requiring the highest levels of machine performance, and their willingness to partner with Komatsu on this key development activity. Customers were asked to not only operate the machines as they typically would do so with conventional Machine Control, but also to test Komatsu’s first fully automatic blade control dozing features which allow automated operation from rough dozing through finish grading.
Customer feedback improves machine performance

During the user seeding activities in North America, I was able to extensively use over 10 years of industry experience as a degreed mechanical engineer. As the local lead, I would like to emphasize that partnering with our customers in this user seeding activity was a win–win scenario for all involved. For our customers, they are now able to purchase a machine with technology and feature sets based on direct end user feedback. For Komatsu, the ability to strengthen the product’s capabilities and validating it in real word customer use on actual jobsites, prior to market release, is immeasurable.

One of the key Komatsu takeaways from the user seeding activities was the importance of steep slope performance in specific applications. Komatsu engineers from Japan were able to witness customers’ use of the pre-production machine on steep slopes which led to the addition of steep slope performance criteria for the final production machine validation to ensure that customer accuracy and performance expectations were met by Komatsu intelligent Machine Control dozers. Komatsu’s Test Engineering Center in Japan was also re-worked to include steep slopes in the configurations encountered during the user seeding activity to ensure this and future intelligent Machine Control dozers meet those same requirements. Being the eyes and the ears at the customer’s jobsite daily for the entire Komatsu team was personally rewarding and emphasizes Komatsu’s desire to fully understand the customer’s application so we can deliver products that become indispensable to all customers’ operations.
Steve Ristow, President of Schneider Excavating Inc., operates the pre-production D61PXi-23 at a Milwaukee, WI residential development jobsite. Steve comments, "I liked it, right on track… great visibility with sloping nose and GPS antenna removed from blade."

Global teamwork speeds development

Reacting quickly to customer requests is very important to keep the user seeding activities progressing. Komatsu and its key development partners leveraged staff across the globe in the development of the intelligent Machine Control technology with personnel participating from Japan, the United States, Australia, and Russia to name a few. In this manner, we were able to make all customer identified improvements in the last round of user seeding activities. While the actual user seeding activities occurred in North America, workload was shared worldwide by the global development team. When a customer requested a change to improve the intelligent Machine Control software or an issue was observed, we were typically able to have that customer evaluating the updated software within one to two days. Just as the sun was setting in North America, our colleagues overseas were able to start working on the updates.

Foundation set for success

To complete the user seeding activities, a final customer focus group and machine performance evaluation were held at Komatsu America Corp.'s customer demonstration and training facility during the fall of 2012. All of the attending customers were expert machine control users: half had previously participated in the user seeding activities, while the other half had not and were acting as fresh independent verification. The success of all the development and improvements made as a result of user seeding enabled the customer focus group to positively conclude the D61PXi-23 was ready for market introduction without further changes. The true measure of success for the user seeding results was shown with the first D61PXi-23 being sold and delivered to a customer in North America without as much as a demonstration. The beauty of the D61PXi/EXi with intelligent Machine Control is that it practically sells itself with its strong value proposition, extensive features and benefits. I can't be more proud of the role Komatsu America Corp. and our customers played in the development of Komatsu’s intelligent Machine Control technology. The future for this scalable technology is very exciting.
Future Potentials of Machine Control Construction Equipment and ICT-intensive Construction

The Root of ICT Applications to Construction and Mining Equipment

Our ICT applications to construction and mining equipment started with KOMTRAX (Komatsu Machine Tracking System) in the last half period of the 1990s. KOMTRAX collects information from GNSS* and sensors installed in the equipment and enables owners to remotely check on machine locations and operating conditions. We equipped our flagship hydraulic excavators with KOMTRAX as a standard feature in 2001. As of March 2013, the number of KOMTRAX-equipped units topped 300,000 worldwide.

Our applications of KOMTRAX data have been evolving, ranging from machine locations, theft prevention by means of locking the engine and credit management of customers being financed in China to supporting fuel-economy operation by using data concerning operating conditions and fuel consumption as well as sending notices for maintenance and parts replacement according to hours of operation of machines. All these activities have been created and carried out independently by our distributors worldwide.

In addition to KOMTRAX, we have been developing and applying new ICT hardware for our equipment, for example, KOMTRAX Plus for mining equipment, KOMTRAX Parts which we are planning to introduce during the current fiscal year, and Machine Control models which we unveiled at the Bauma trade fair.

We have been evolving ICT applications dynamically, but you can still find a common approach or the same root in all our different systems. Our ICT applications are a system to make “visible” how our machines are being used by customers on their jobsites. Accordingly, it is the purpose of ICT applications that we develop and provide customers with services which are truly valuable for them (solutions) by using “visualized” data.

* GNSS: Global Navigation Satellite System is a general term for navigation systems, which are developed by different countries, e.g., GPS by the United States and GLONASS by Russian Republic.
ICT-intensive Construction Equipment to Transform Construction Jobsites into Manufacturing Plants

By focusing on this root, we have developed D61EXi/PXi Machine Control bulldozers and our PC210LCi pilot Machine Control hydraulic excavator to propose as our DANTOTSU solutions, a higher-level service, and we displayed them at the Bauma trade fair.

Featuring the world’s first fully automatic blade control, D61EXi/PXi models perform high-precision blade control, comparable to veteran operators, from rough dozing to finish grading according to 3D design information. It can also offer a high-precision, real-time survey of landscape upon completion of work by using GNSS.

I believe that we should be able to achieve a high-end civil engineering and construction workflow in the near future, where each and every D61EXi/PXi and PC210LCi model seamlessly performs all needed tasks, from surveying to excavation, finish grading and inspection surveying, and feedback through real-time progress reports and as-built data (after-work landscape information). We are studying a system which will link the daily operational data of D61EXi/PXi bulldozers to KOMTRAX, thereby "visualizing" construction jobsites, as if they were manufacturing factories in order to further improve customers’ operational efficiency.

Especially in North America, post-construction inspection is accepted in the form of GNSS survey data, which had widespread ICT-intensive construction earlier on and made good progress.
What Is The True Value Expected on Jobsites?

We can reasonably believe that not all customers want high-end construction. In some emerging countries, for example, customers want to train machine operators and make more efforts on attendance management of workers. What is expected of us by our customers differs greatly, depending on individual customers’ needs.

As I have mentioned above, the root of our ICT applications goes back to our "visualization" of customers’ jobsites where our machines are used. Accordingly, what we must do calls for facing our customers straight on with obtained data, getting involved in their jobsite work and working to generate ideas together with them and create truly valuable solutions. Therefore, Machine Guidance or Machine Control construction equipment is only one of our attempts.

We at Komatsu define our brand management as focusing on customers, deepening our relationship with them, looking into their vision and working together with them to achieve it. I believe reinforcement of this brand management approach and promotion of ICT applications to products are the paired wheels.

DANTOTSU (Unrivaled) Solutions are not born from ICT but always from customers’ jobsites and continue to grow there. We are committed to promoting ICT applications to our machines from jobsite and customer orientations.