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# motion world

Trends in CNC automation

2018

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With PreciProtect, Huron created a solution for sustainably avoiding collisions in its machining processes

## Editorial

- 03 Implement now! – Gain a competitive edge through digitalization

## Cover story: Digitalization

### Get started with digitalization today

- 04 Siemens is presenting a comprehensive portfolio of industrial network solutions at the major fall trade fairs

## Technology

No fear of crashing —  
Not even at 100% override

- 09 Sinumerik 840D sl and PreciProtect offer comprehensive collision protection

Milling at its best

- 14 New milling technologies for fast and safe precision machining

Completely CNC-integrated robots

- 18 Lean, flexible manufacturing with robots —  
Without separate robot controls thanks to Sinumerik Run MyRobot /Direct Control

Large-format high-performance machining

- 23 With Sinumerik 840D sl, huge impellers are manufactured flawlessly at the Siemens plant in Duisburg, Germany

## Digitalization

Everything runs smoothly in live production

- 26 At Maka, virtual commissioning from Siemens saves time and money

## Automation

The best of both worlds

- 28 GKN Aerospace relies on the advanced Sinumerik 828D CNC for retrofitting a 3-axis milling machine

High-precision manufacturing for the aviation industry

- 30 Machines from Mazak and Sinumerik controls help ensure the success of Chester Hall



# Implement Now! – Gain a competitive edge through digitalization

There is no end to digitalization. Over the past few years, the key topics discussed regarding digitalization in the machine tool industry were basic issues in regard to technological opportunities as well as areas of application. This applied not only to processes within an organization, but also to the value-adding network of suppliers, manufacturers and customers. In the meantime, it has become clear that digitalization is by far the most significant factor for achieving more productivity and greater efficiency.

By now, we have entered the next phase of the digital transformation. "Implement Now!" is the key message being emphasized by Siemens in dialogue with its customers. That is because, when it comes to digitalization, there is a golden rule: Only those who do nothing are making a mistake.

The size or level of complexity of your digitalization project is not crucial – what is decisive is that companies pursue this path. By doing so, companies will learn what advantages digitalization delivers in real-world scenarios, but also what difficulties have to be mastered. The experience gained in digitalization by our own Siemens plants and generally within our organization has convinced us this is the right path to follow.

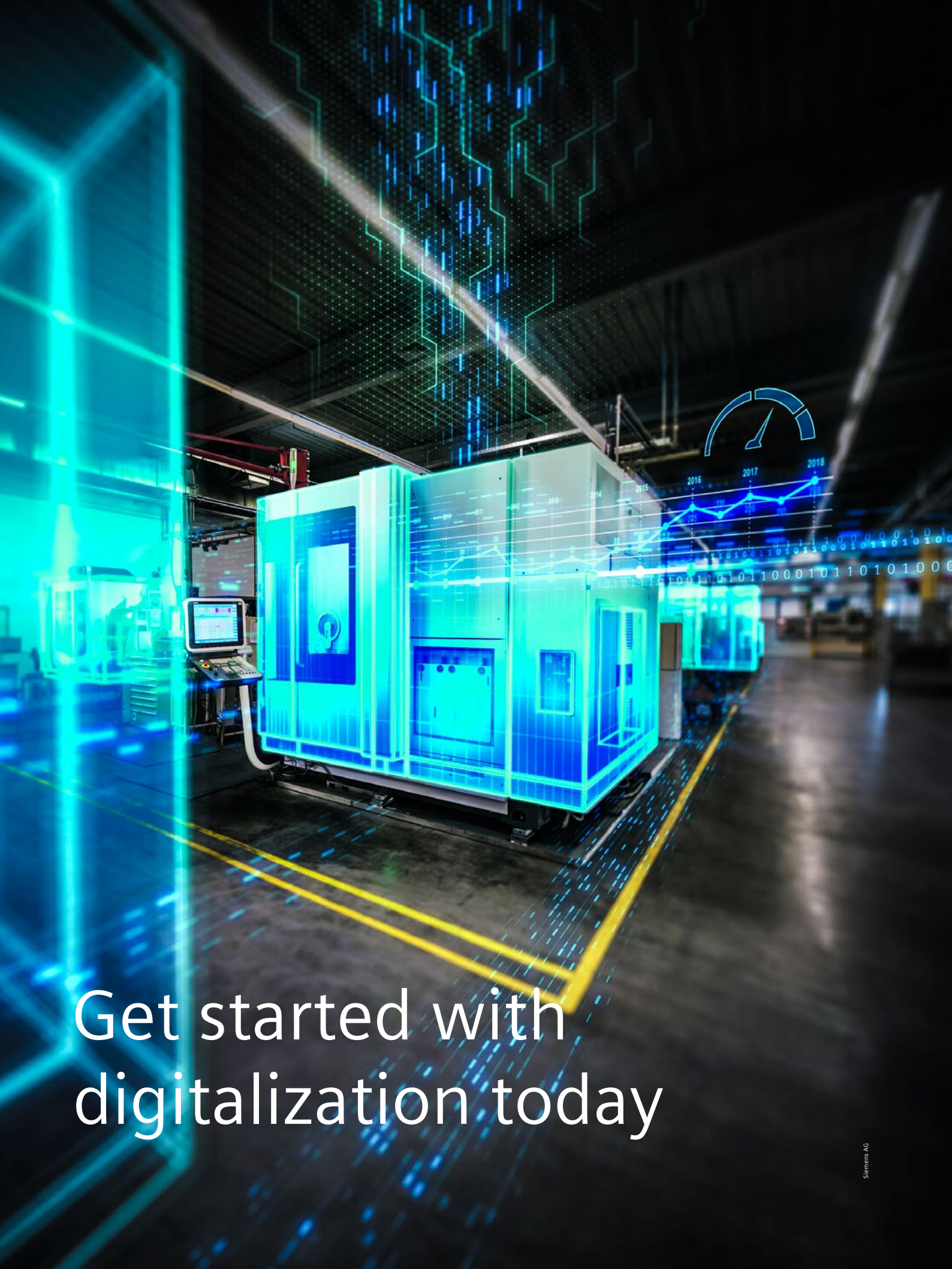
Do you want to take advantage of opportunities made possible by digitalization? This issue of motion world will show how Siemens is helping advance digitalization in the machine tool industry, what our comprehensive, integrated, and seamless digitalization portfolio looks like, and what highlights await you at the Siemens booths when attending the international IMTS, JIMTOF, AMB, and SPS IPC Drives trade fairs this fall.

We look forward to seeing you there so you can experience the fascinating Siemens world of the digital factory for the machine tool industry.

Sincerely,

**Dr. Wolfgang Heuring**  
CEO Siemens Digital Factory  
Motion Control





Get started with  
digitalization today

**Digitalization:** IMTS, JIMTOF, AMB, SPS IPC Drives: this fall, international machine tool trade fairs will be focusing on networking and digitalization. Under the theme “Implement now” Siemens will be showcasing an ever-expanding portfolio of solutions that will quickly deliver noticeable competitive advantages to both large and small machine tool operators and machine builders.

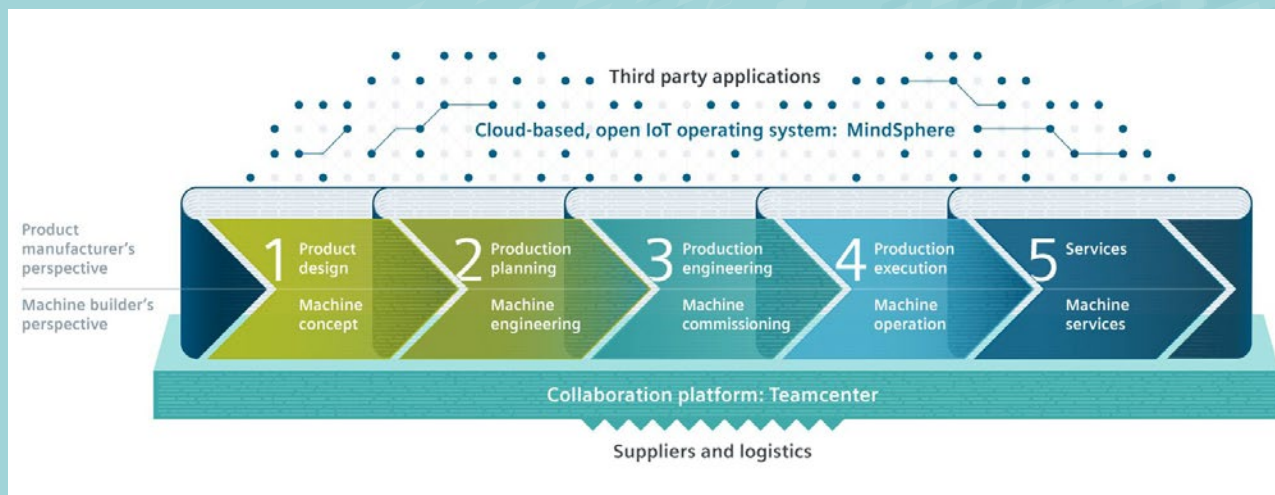
Discussion surrounding the digital transformation in the machine tool industry is changing. While debate used to center on questions about basic technologies and general feasibility, now attention is increasingly turning to concrete implementation within companies. In other words, digital transformation projects have to be subject to the traditional investment questions: What goals and priorities is a company pursuing with the project? How can it be implemented in a technically reliable and organizationally efficient manner? When will the investment pay off?

#### An expert consultant for digitalization projects

One major challenge is the fact that, while digitalization projects can be implemented gradually, they should not be looked at in isolation. After all, the greatest added value is generated wherever solutions and processes are considered holistically. This is where Siemens steps in as the provider of a comprehensive digitalization portfolio for the machine

tool operator’s entire value chain: from design, planning, engineering, and execution, through to services.

For example, machine tool operators and manufacturing firms can now seek assistance before making decisions about digitalization projects. With its Digital Motion Control Services, Siemens offers extensive consulting services for digitalization in mechanical production — from decisions regarding potential goals and priorities to product evaluation, process and data analysis, and ROI calculations, all the way to support in implementing concrete hardware and software solutions. Managers can carry out a digitalization check on their company, draw up a plan for digital transformation, then break it down into specific sub-projects for step-by-step implementation. Consultancy services from Siemens give companies access to experienced digitalization experts who have worked in the machine tool industry for years and are thoroughly familiar with the relevant processes.



Siemens offers integrated software and hardware solutions — from the initial idea right through to service. They provide a seamless connection between the virtual and the real world of product development and production



# The major fall trade fairs, 2018

## Booths:

### IMTS Chicago

September 10–15, 2018 / East Hall / 134502

### AMB Stuttgart

September 17–22, 2018 / Hall 2 / B03

### JIMTOF Tokyo

November 1–6, 2018 / E 5007

### SPS/IPC/Drives

November 27–29, 2018 / Hall 11

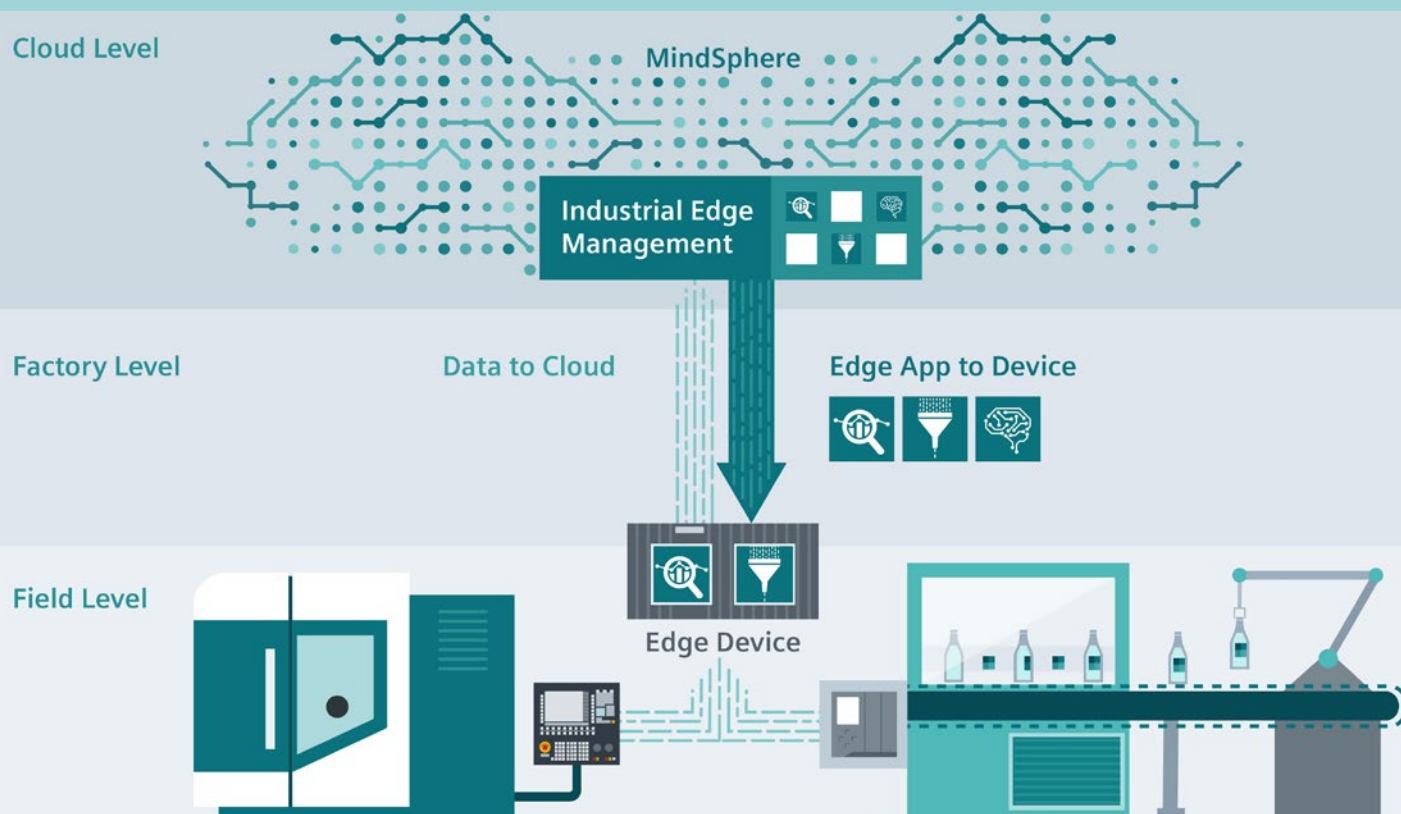
## Key areas of focus:

- Integrated digitalization solutions with CNC Shopfloor Management software for machine builders and machine tool operators (in machine, in line, in cloud)
- Digitalization consulting: Digital Motion Control Services
- Siemens Industrial Edge, Sinumerik Edge, and apps for monitoring, control, and service
- MindSphere version 3.0 and MindApps for monitoring, control, and service
- Virtual Commissioning Services
- Visualization of machining processes on the digital twin
- New standard for the medium-sized machine segment: Sinumerik 828D SW 4.8 SP3
- Robot integration with Sinumerik Run MyRobot
- Technologies: milling, turning, multi-tasking, additive manufacturing
- Sinumerik Operate with side screens and display manager

## Sinumerik Edge: Bringing the power of IT to your machines

A question often asked by CNC users when implementing digitalization projects is: How can the control system and CNC machine work together accurately and reliably — while delivering and analyzing a large volume of real-time process data at a high frequency?

The answer from Siemens is Edge computing, more specifically the digitalization platform Siemens Industrial Edge, that adds machine-oriented data processing to automation devices. Sinumerik Edge delivers this approach to CNC production. The special Sinumerik Edge computer units give CNC machines comprehensive networking and digitalization capability, making it possible to collect, analyze, and aggregate process data, and then communicate them to company servers or cloud solutions — without placing strain on the machines. At the same time, Sinumerik Edge offers a smart solution to the challenges of networking, bandwidth limitation, software installation, updates, and upgrades. Sinumerik Edge provides a local machine interface to the company's internal server network, but apps — small, flexible program modules for computing and control functions — can also be installed, just as on a smartphone. These applications are installed and updated remotely at the press of a button, either via the company network or using the MindSphere cloud platform.



The principle of Siemens Industrial Edge: computing-intensive digitalization functions run on local hardware, Edge apps are provided via MindSphere. These apps use the CNC data and are operated on the CNC operator panel but they actually run on the Edge device, without inhibiting the performance of the CNC

### Higher Productivity with Edge apps

The apps demonstrate the options and possibilities Edge computing offers. The Optimize MyMachining /Trochoidal Edge app, for example, is run directly on the machine and supports the complex tool path calculation for highly efficient, extremely precise trochoidal milling. Condition monitoring is another application scenario: the data transferred from the CNC to the Edge hardware derives information about the state of wear and need to optimize the drive controller once again. This information is used by the Analyze MyMachine /Condition Edge App: By regularly monitoring the status of the axis and comparing them with a reference status, deviations can be discovered at an early stage and production downtimes are avoided with status-oriented maintenance.

### Locally or remotely

The Manage MyMachines /Remote MindApp rounds off the Edge-based condition monitoring. It allows users with appropriate authorization to access the machine via the cloud and make changes such as adjusting set-

tings or installing programs. This makes the app perfect for efficient remote access, either by internal technicians at other sites or by the manufacturer's support team. It all happens quickly, securely, and without travel expenses — even when using a heterogeneous control environment.

### Flexible digitalization: in machine, in line, in cloud

With Sinumerik and Sinumerik Edge (on the machine level), Sinumerik Integrate (on the shopfloor level and via the user-operated server network), and the industrial cloud platform MindSphere version 3.0, Siemens provides flexible and integrated networking and digitalization platforms at all levels of operation. This means that the machine operator is free to choose an individual path with personalized priorities in digitalization projects, while always remaining open and scalable. In short: there are solutions available at every level, expenses and benefits can be calculated — and companies can get started on implementing digitalization.



The virtual image of the machine benefits machine builders and operators in a wide variety of applications from the machine concept and commissioning all the way to retrofitting and servicing

## Digital twin: Adding more flexibility

The systematic digitalization of the development process is opening up a world of new potential for machine builders: a digital twin of the machine, used in every phase of the process, provides all the data needed early-on in a virtual model of the machine, significantly increasing flexibility. Machine operators also benefit from that.

With digitalization, a virtual machine model is created early in the development process. This digital twin supports optimization of the new machine design — from virtual commissioning, marketing the machine, running in parts in production, to retrofitting and servicing. This saves machine builders a large amount of time and increases the quality of their machines — from the concept right through to production.

### Digitalization facilitates faster machine development ...

The NX Mechatronics Concept Designer makes it possible to significantly shorten the machine development process. Thanks to virtual commissioning, the capital-intensive phase of the actual commissioning process is substantially reduced. To achieve this, the digital twin is connected to the real Sinumerik so that machine functions can be tested and optimized under almost real conditions.

With NX Virtual Machine Tool Services, the customer service team offers new services for creating digital images of customer machines and integrating them in the customer environment. This makes it possible to increase productivity and reduce the risk of damage to

any machine controlled by Sinumerik 840D sl, regardless of the manufacturer. Extensive training and support ensure customer employees are qualified and thoroughly familiar with the use of NX Virtual Machine Tool and maintenance of the virtual machine.

### ... and shortens the production process

The digital twin allows companies to plan and optimize all stages of production before the new machine is even up and running. For example, a virtual twin of the machine and Sinumerik CNCs allow programming and setup processes to be transferred to the PC. This reduces setup time while increasing profitability. By using the original Sinumerik software — the virtual NC kernel (VNCK) — a virtually identical simulation of machining is possible for making optimizations in advance. This avoids machine downtime during operation. ■

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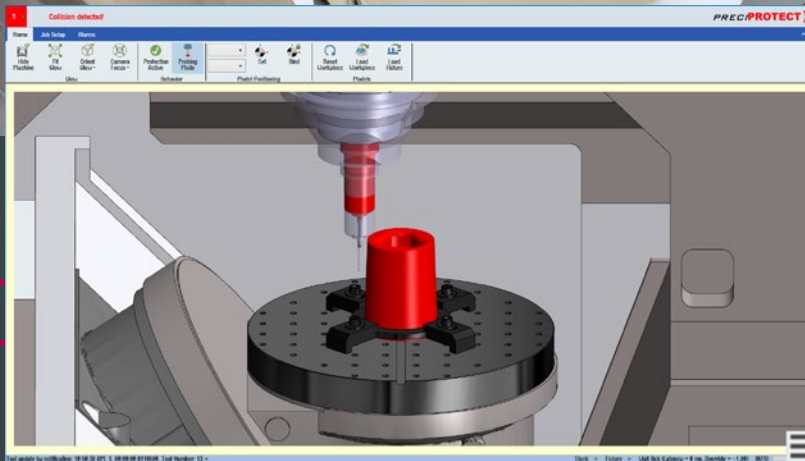
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# No fear of crashing — Not even at 100% override

**Technology:** Machine builder Huron offers effective protection for its machine tools equipped with Sinumerik 840D sl CNC: PreciProtect stops the machine before a crash occurs.



All Sinumerik CNC modes, including the measurement process as well as any relevant equipment benefit from collision avoidance

The benefits of a comprehensive collision avoidance solution are clear: each crash that can be prevented when machining workpieces saves time, effort, and money. Precise and comprehensive information about job sequences in the machine space has to be processed if potential collisions are to be detected reliably and prevented effectively. Everything that might interfere with the programmed motion sequences needs to be taken into account.

### Reliable collision avoidance prevents costly damage

With its PreciProtect collision avoidance software, machine manufacturer Huron has succeeded in mapping the time-

line of the machining process far enough in advance for the machine to automatically and safely shut down before a collision occurs. "This is important in shopfloor manufacturing, for example, where machines have to be set up again and again, or for machine operators who place high demands on the workpiece surface and can't tolerate any damage," explains Yan Boutin, head of innovation and development at Huron. "This is a particularly relevant consideration for expensive, certified workpieces, because even the most harmless collision may have serious consequences." Using PreciProtect collision avoidance is advisable in tool and mold making, for example, where even inadvertent contact between the tool and workpiece may leave marks on the workpiece that are visible on





*»The complexity of PreciProtect is not obvious to the user — we have gone to great lengths to ensure the collision avoidance is extremely safe and easy to handle.«*

Bernard Echevard, General Manager, Huron

molded parts. These marks may seriously impair workpiece functions, with potentially fatal consequences, especially regarding workpieces used in the aerospace industry.

#### **A complex but user-friendly solution**

The five-axis, high-performance gantry milling centers in Huron's new modular, automatable KX Five series have been specifically developed for industries with the most exacting requirements. The milling centers achieve best-in-class surface quality at high machining speeds. This is possible thanks to torque motors allowing maximum axis rotation speeds for high-speed five-axis machining. The Sinumerik CNC also has an important role to play in this, says Boutin: "On the one hand, this extremely powerful CNC is capable of transferring the high precision of our machines to the workpiece rapidly and reliably. On the other hand, it features a number of key cycles for model and mold making and offers efficient functions for high surface quality. This serves as the foundation for the PreciProtect collision avoidance system we have developed, which now allows us to comprehensively safeguard the machining process."

The basic collision avoidance software comes from ModuleWorks. The Siemens product partner developed PreciProtect in cooperation with Yan Boutin and his team and with Siemens, thus creating a powerful collision avoidance system for Huron machines with intuitive operator control. Bernard Echevard, general manager at Huron: "We have responded to our customers' requirements by launching a unique, innovative solution. The complexity of PreciProtect is not obvious to the user — it's quite the opposite, in fact. We have gone to great lengths to make sure the collision avoidance is extremely safe and easy to handle. After all, its purpose is to

enable our customers to be confident enough to leave their machines alone, even if a €1,000 workpiece is being machined."

#### **Careful set-up pays off**

In order to reap the benefits of the collision avoidance system, users have to set it up for the specific machining task first — an extra overhead that quickly pays off. To achieve this, the geometry of all components involved must be defined precisely. A library containing 3D models of the machine, clamping fixture, tool carrier, tools, and the workpiece or blank supports the machine operator in this task. These models form the basis for a fully animated, 3D simulation of the machine. Material removal is dynamically factored in during real-time machining. Other details essential in industry practice are considered. For example, with non-center cutting tools, where there is a high risk of collision when positioning machines on inclined planes, cutting edges are displayed exactly, not just as an approximation. Angle heads which, for reasons of productivity, are being used more and more frequently for six-sided machining and significantly increase complexity, can also be fully integrated in collision avoidance.

#### **PreciProtect as a real-world application**

Before machining can start, the operator has to mechanically set up the machine and synchronize the setup virtually. This is done using CAD models of the workpiece, a clamping fixture and tools, which are usually available from the CAM system. The resulting simulation provides a reliable reflection of reality. Any parameter changes required for this are displayed in real time in the simulation environment. Because PreciProtect runs seamlessly with all the inputs available in all Sinumerik CNC modes, nearly all JOG mode and measurement process operations as well as any relevant equipment benefit from collision avoidance. >



All processes can thus be carried out as usual — but with significantly increased safety. After the workpiece and zero points have been measured and the acquired data transferred, the system knows every last detail about the machining area. Simulation and reality therefore match to the highest degree possible prior to the start of NC. Dynamic material removal ensures it stays that way during machining.

#### **Clearly structured 3D visualization**

All settings can be clearly and transparently identified on a specially developed, optimally arranged 22" touchscreen operator panel. This panel not only displays the CNC user interface, Sinumerik Operate, but also provides a 3D view of the machining process, any live images from cameras in the machining area, and other evaluations. The display can be configured to individual requirements. The dynamic 3D representation of the actual machining process is supplemented by a semi-transparent view that shows what is about to happen using the look-ahead function. As Boutin explains, this is where the Collision Avoidance Advanced function of the Sinumerik 840D sl CNC comes in: "The pre-processing time is selected so that the simulation can be visually tracked by the machine operator while also leaving enough lead time for the machine to be stopped safely whenever necessary, so that a collision does not occur." If a potential collision is detected — for example, if the milling spindle is not rotating before it makes contact with the workpiece — the machine stops in time and the components involved are displayed in red. The 3D representation helps to clearly identify the problem at hand. It can be rotated and magnified at will, and if a component

interferes with the view it can be hidden. Events are displayed on the panel completely recognizably for the operator, even if cooling lubricant in the machine impedes the view. The operator is thus given the best possible help in resolving any problems.

#### **More time saved, less machine downtime, and lower repair costs**

Safe in the knowledge that the machine will stop in time if necessary, even machining processes that previously had to be carried out under close supervision can now be left unattended (known in the industry as "lights-out machining"). PreciProtect effectively protects against collisions ranging from machine crashes to light, unintentional contact with the workpiece, and thus offers a range of benefits: First, it saves time as no advance simulation is required and control/protection take place in real time. Second, it increases profitability, as costly machine downtimes and repairs are avoided and the high precision of the Huron machines is reliably maintained. The more complex and expensive the workpiece and the farther along the machining process, the more crucial workpiece protection becomes. But the protection does not stop at workpieces, because tools, probes and other equipment — some of which is extremely expensive — are also safeguarded. Thanks to PreciProtect, Huron has created a solution that protects the machining process on a lasting basis. ■

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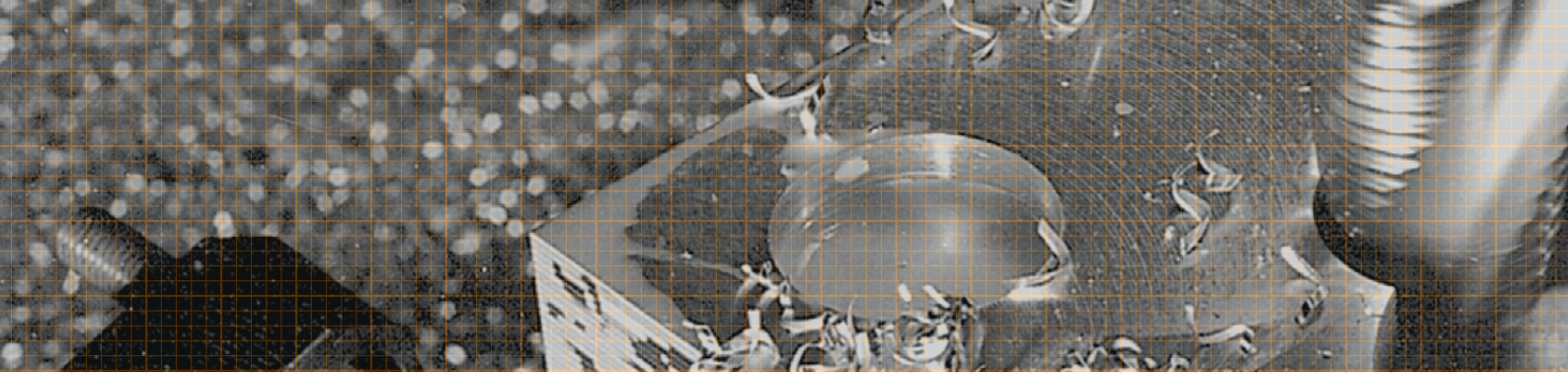
*»The high-performance Sinumerik 840D sl CNC features a number of key cycles and efficient functions for high surface quality, and it forms the basis of the PreciProtect collision avoidance system we have developed.«*

Yan Boutin, Head of Innovation and Development, Huron



Siemens / Huron





# Milling at its best

**Technology:** Precision and speed are crucial factors in milling productivity. With the release of version 4.8, Sinumerik now offers an array of new functions significantly improving the speed, precision, and safety of milling tools. In addition, Siemens Mechatronic Support has developed a wide range of control functions to compensate for milling deviations.

## Enhanced precision requiring less machining time

The new 4.8 software release includes features for the CNC Sinumerik 840D sl that further increase productivity: high milling accuracy, minimal post-processing, compensation for physically unavoidable machine deviations, and protection against collisions. This means a finished workpiece can be safely milled with the usual accuracy in less time.

### Top Surface

The Top Surface function allows high surface accuracy to be achieved that is nearly independent of CAM input. As a result, CNC machine operators can almost always use standard values for contour and orientation tolerances.

Top Surface eradicates aberrations occurring in many NC programs used in tool and mold making in particular.

By adapting the speed profiles of neighboring milling tracks and specifically smoothing contours, the surface finish is optimized while minimizing workpiece post-processing. The smoother motion paths also optimizes the acceleration and jerk behavior of machines. The milling machines thus run more smoothly and wear is reduced.

### Precise milling with CYCLE9960

CYCLE9960 automatically runs cycles for measuring the kinematics of rotary axes.

It provides the necessary process reliability for carrying out highly complex milling tasks on five-axis machines. Thanks to its almost completely automated processing, CYCLE9960 helps improve productivity. And thanks to its ease of operation, measuring can be done quickly, saving valuable machining time.

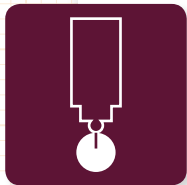
The measurement cycle and downstream kinematic compensation can monitor and reset the accuracy of rotary axis kinematics at any time. This can be done quickly, easily, and with a high degree of precision without any service personnel or special equipment.





### Two types of collision avoidance

Sinumerik's collision avoidance has been developed further and is now available in two versions: The Eco



version implements simple, reliable machine protection and prevents collisions of the machine bodies in the machining space. This collision avoidance is available in all operating modes; the protected

areas can be easily and efficiently configured and visualized as a 3D image at the control interface. The Advanced version offers an even higher level of safety during machine operation. Together with Sinumerik CNC, the Advanced version ensures the machine, tool, tool holder, clamping fixture, and workpiece all remain visible and dynamically protected in real time during material removal. The software runs on an external computer via an interface.

### Dynamic positioning with the Adapt Jerk Filter Time (AJET) feature

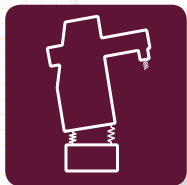
Rapid traverse positioning — without tool engagement — has to be executed as quickly as possible. Sinumerik CNC uses the Adapt Jerk Filter Time (AJET) feature to adjust the dynamics for these positioning tasks: The dynamic performance of the motion increases without



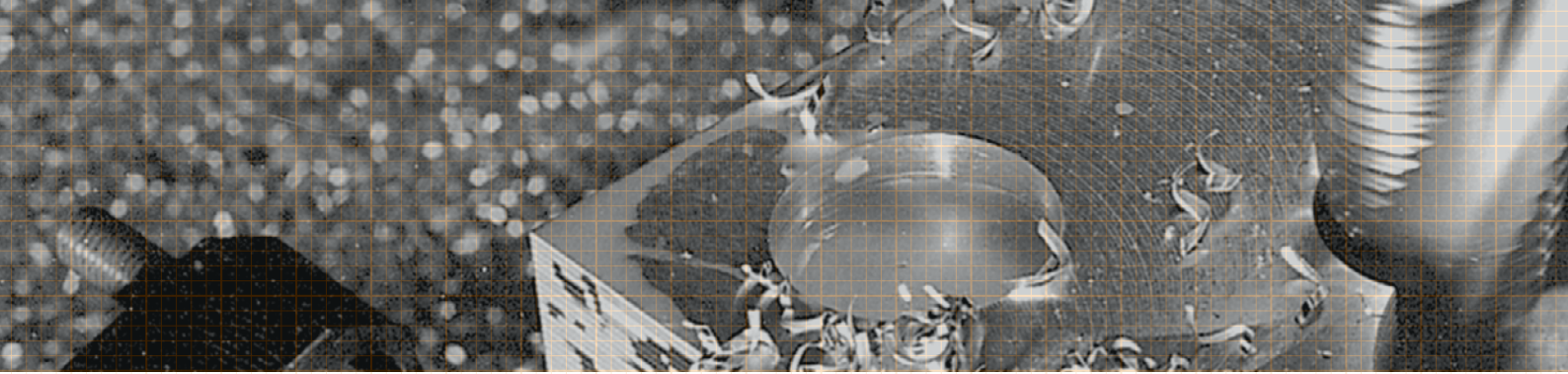
reducing the workpiece positioning accuracy for the next workpiece operation. A special feature of AJET is that, although high jerk values are involved in the required rapid traverse motions, the unavoidable vibrations during positioning are still suppressed. Deploying AJET allows program run-times to be reduced by a single-digit percentage factor in series production.

### Working quietly in the background: Nodding compensation

Nodding compensation is a hidden function: you only realize it is there if it is not applied. Nodding compensation allows jerk values to be increased, reducing machining times and improving machining quality. Caused mostly by acceleration, unwanted machine axis responses such as tilting motions may lead to workpiece inaccuracy if no nodding compensation is used.




These types of errors can usually be offset by motions against other axes so the tool center point (TCP) is not adversely effected. Nodding compensation for Sinumerik is available in two versions: Eco and Advanced.



## Special functions compensate for mechanical engineering deviations


In addition to nodding compensation, other compensation functions reduce unavoidable deviations that can negatively affect the dynamic performance, accuracy and, ultimately, machine productivity. Specialized Siemens Mechatronic Support staff helped develop this control function in order to optimize the production accuracy of a machine for the virtual prototype as well as during and after commissioning of the finished machine. How machine builders benefit: Development risks and the time needed for new machine development are reduced while the production of commercially viable machines with less effort is accelerated.

### **Cogging torque compensation for highly smooth surfaces**



Because of the permanent magnets in linear and torque motors, forces of attraction occur between primary and secondary parts. These forces produce cogging torques and periodic torque ripples during machining. In applications that require a very high-quality surface finish, torque rippling will cause minuscule position deviations on the tool's gripping points, which then become visible on the workpiece — such as along the milling path. Cogging torque compensation identifies these periodic transmission deviations as parasitic frequencies and compensates for them by switching to a relevant compensation torque via the torque pre-control.

### **Learning Control: CNC error memory**



The Learning Control function allows teaching in of deviations in CNC signals and their compensation when a process is repeated. This algorithm works much like a memory for a predetermined process and compares the position setpoint with the actual position value. If unwanted deviations occur, compensation signals are applied in order to minimize the difference between setpoint and actual values. Learning Control can offset deviations that may arise from the drive system or the machining process.



### Compensating for friction errors

Whenever a mechanical axis comes to a stop and has to start up again, small delays occur because enough power must build up to overcome the inertia of the drive and its static friction to set the axis in motion again. Because this effect is easy to reproduce, it can be offset by a minimal surge in speed or current. Sinumerik can now account for a wide variety of acceleration and speed ratios for this operation.



### VCS — volumetric compensation corrects minimal deviations

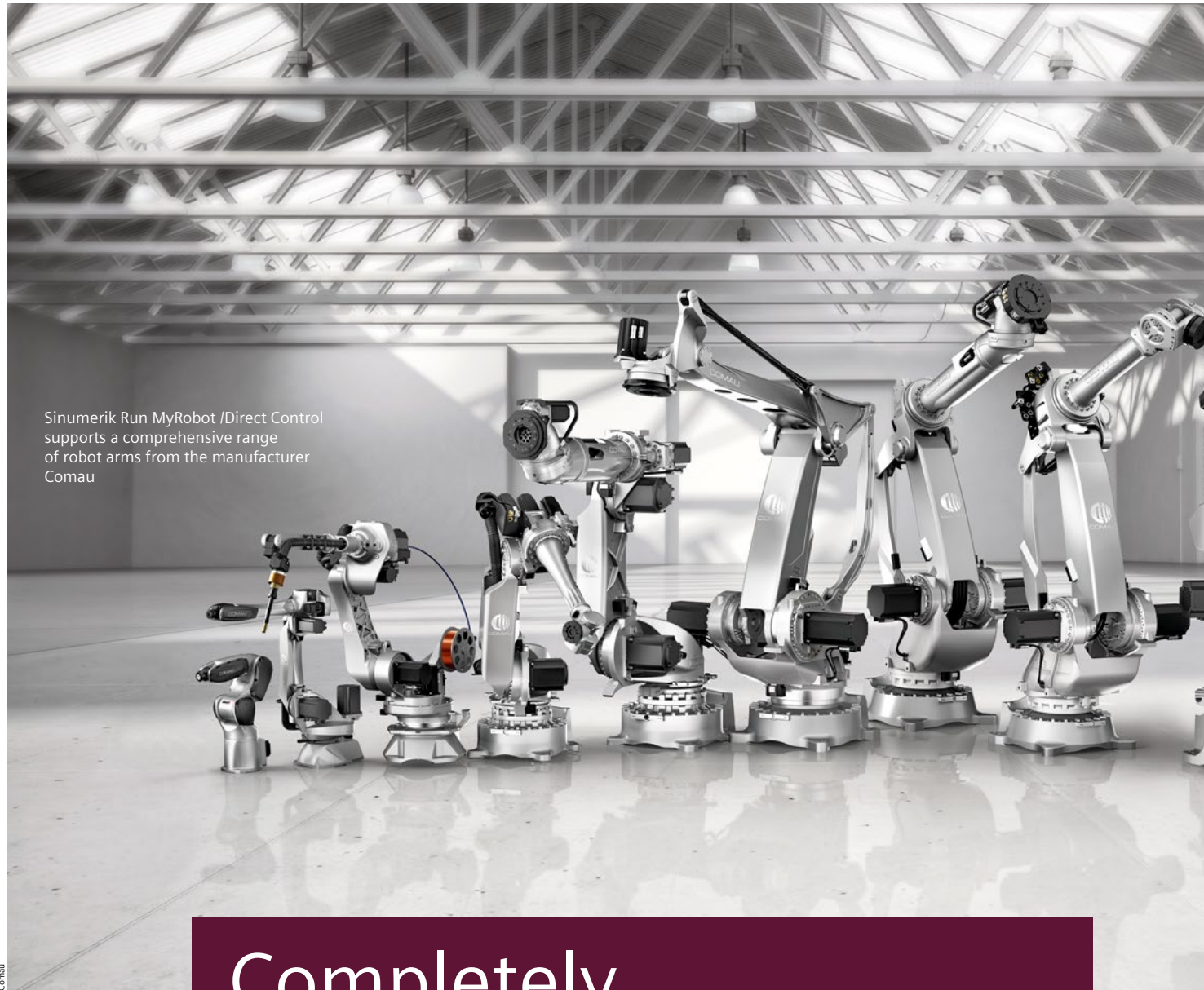
The mechanical properties of a machine are never ideal. Position and orientation errors occur at essentially every feed axis due to, among other things, linear and rotational deviation. The total error from the interplay of all axes is known as the volumetric error, meaning the deviation of the tool center point (TCP) from the ideal position programmed. In general, the bigger the machine, the bigger the deviation. Volumetric compensation is carried out by measuring all machine axes with a laser device, recording the values in a compensation table, and sending this to the control system for correction. ■



### Value-added features of Sinumerik 840D sl at a glance

- Top Surface for high-quality surface finish accuracy
- CYCLE9960 enhances process reliability for highly accurate milling
- Improved collision avoidance against machine body collisions
- Adapt Jerk Filter AJET adapts path dynamics during rapid traverse
- Nodding compensation increases the jerk values of a machine
- Cogging torque compensation enables best-in-class surface finishes
- Learning Control compensates for CNC signal deviations by means of learning
- Friction compensation prevents minor contour errors
- VCS — volumetric compensation corrects position and orientation errors





Sinumerik Run MyRobot /Direct Control supports a comprehensive range of robot arms from the manufacturer Comau

# Completely CNC-integrated robots

**Technology:** Robots mounted on machine tools are an ingenious and efficient way to achieve lean, flexible manufacturing. Sinumerik Run MyRobot /Direct Control operates articulated-arm robots without the need for a separate robot control system — an approach that is easy to engineer with minimal replacement parts needed.



*»System consistency, programming, maintenance, diagnostics, service, and spare parts inventory all benefit from integrated robot kinematics.«*

Machining center potential can be more fully harnessed through the use of articulated-arm robots because they reduce reaction time, make operator-free production possible without expert technical staff having to perform monotonous tasks or handle heavy workpieces. With Sinumerik Run MyRobot, Siemens offers several options for connecting robots to machine tools. This ranges from a VDMA interface solution all

the way to complete operation, programming, commissioning, maintenance, and diagnostics of the robot via the CNC.

#### **Direct CNC robotics**

Until recently, the machine control system was required for communicating with the robot control system. Today, doing so is easier: Sinumerik

CNCs can now control robot mechanics directly by using specific algorithms. In Sinumerik Run MyRobot /Direct Control, the CNC also assumes control of the robot arm drive and implements the necessary safety functions.

The systematic integration of the robot connection within the Sinumerik CNC extends the range of robots supported.

In addition to its proven partnership with robot manufacturer Kuka with Run MyRobot /Handling and /Machining, Siemens now also works with robot manufacturer Comau on /Direct Control.

### High availability and a lean overall system

CNC integration offers further benefits: The physical space previously required for the proprietary robot control system is no longer needed. The number of support staff for questions about electronics, control systems and programming for the robot-assisted manufacturing stations decreases as well, cutting costs and reducing project risks.

Because the CNC is now solely responsible for the entire system of machine tool and robot, improvements are achieved in system consistency, homogeneous operation, programming, maintenance, and diagnostics, and service and spare parts inventory are enhanced. Last but not least, this all has a positive effect on the error rate: the now significantly leaner overall system is less prone to errors and thus has better availability.

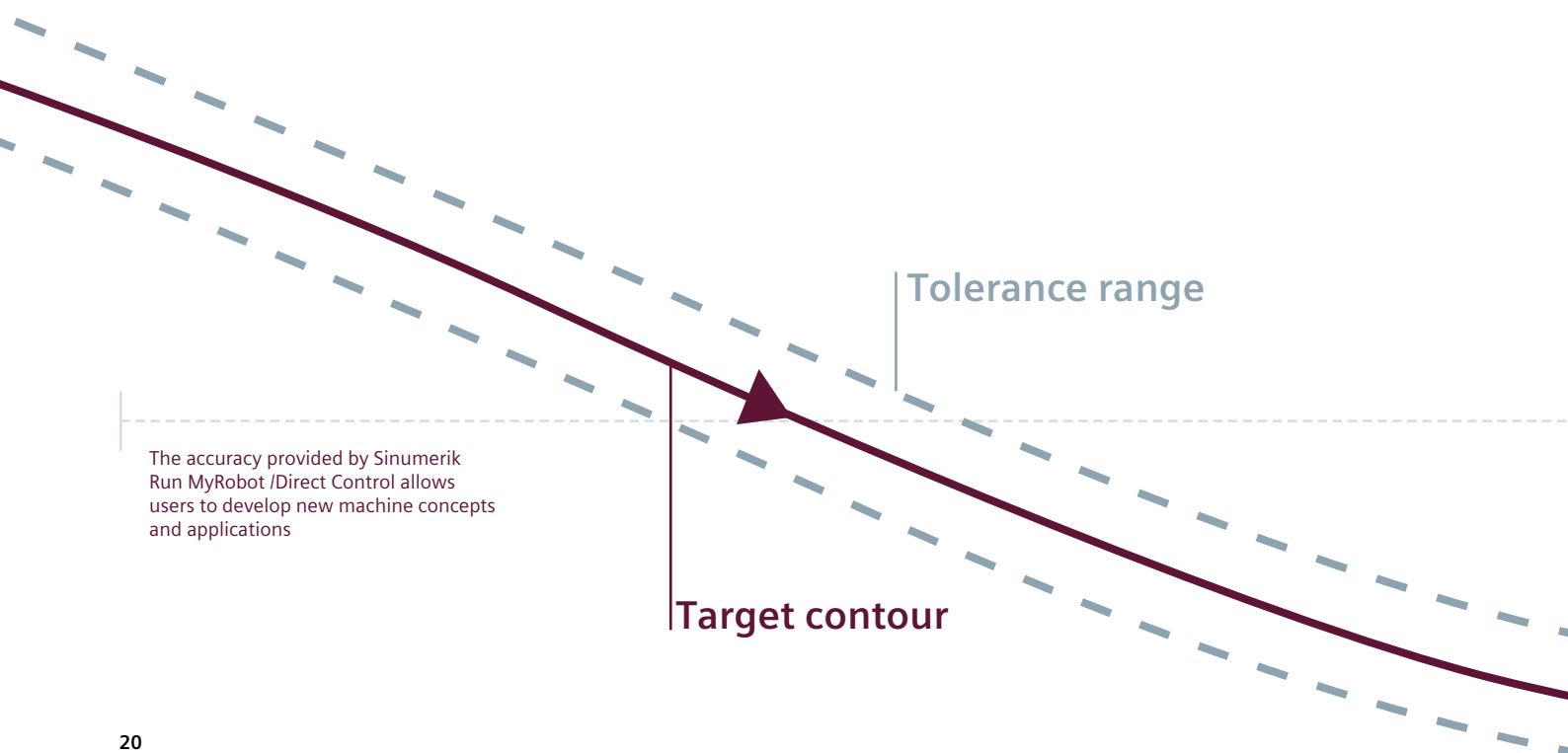


Full integration of robots within the CNC system simplifies robot-based machining of parts and the integration of CNC machines within flexible manufacturing networks

### Drive control via CNC for improved dynamics and precision

By integrating robot drives within the CNC, all CNC strategies for increasing precision now also affect the robotics. This improves the accuracy and dynamic performance of path guidance and positioning. The robot also takes over additional or more complex machining steps

and also works in parallel more frequently. Innovative and sophisticated robot-supported manufacturing processes such as fiber placement, additive manufacturing, the milling of numerous materials, as well as CFK and laser processing all benefit from this. These processes can now be implemented more easily thanks to the use of standardized products.





For highly demanding requirements, Run MyRobot /Direct Control includes optional intelligent calibration and compensation functions — with customized optimization from the automation partner's Mechatronic Support, if required.

### Simple configuration and commissioning

Sinumerik Run MyRobot /Direct Control includes operation and programming options for existing Run MyRobot versions. This means all CNC programming methods, from conventional to cycles and high-level programming language can all be used with the robot, including graphics programming with programGuide.

The widely known teach-in technique of approaching reference points for a robot action in JOG mode is significantly easier, because with Run MyRobot, the robot arm is directly controlled using the machine or work-piece coordinate system. The CNC automatically takes active coordinate transformations and machine kinematics into account — a major advantage for robot teach-in on machines with swivel axes. For experienced machine tool operators, little time is spent getting used to robotics-related issues. Existing CNC expertise is sufficient — also for robot maintenance and diagnostics.

Siemens provides full configurations of the necessary electronic engineering and software components for every supported robot arm in the Sizer

configuration tool. Robot configuration is thus limited to entering the correct configuration into the engineering project. Commissioning is just as easy: using a configuration tool, robot-specific machine and drive data can be easily uploaded to the CNC control system. The CNC then uses this tool to initiate operation of the robot arm in an automated, operator-free process.

### Digital twins for realistic simulation

Digital twins are available for use in NX CAM Robotics for robot arms compatible with Run MyRobot /Direct Control. In the kinematic 3D robot model and Sinumerik virtual NC kernel (VNCK), virtually identical simulation of part programs generated in the CAD/CAM-CNC process chain allows the robot, part programs, and the CNC system to interact seamlessly. This reduces the time needed for verifying and optimizing robot actions in advance.

### CNC-integrated robotics enhances production

In this initial phase of the partnership, Sinumerik Run MyRobot /Direct Control already supports a good dozen robot arm models from Comau. The robot manufacturer provides advice on robot arm selection and delivers it with all motors and cables required for operation with the system pre-installed.

Sinumerik Run MyRobot /Direct Control allows the complete integration of robots in the CNC, the CAD/CAM-CNC chain and engineering process.

### Highlights of Sinumerik Run MyRobot /Direct Control

- Path control with Sinumerik CNC technology
- Extended range of robots supported
- A high level of system consistency
- Lower probability of errors
- Intelligent calibration and compensation functions
- Simplified configuration and commissioning
- Digital twin with NX CAM and VNCK

Sinumerik Run MyRobot /Direct Control thus takes advantage of all the benefits provided by a robot-based system: a consistently homogeneous system landscape and seamless data flow across all system levels. This has made it significantly easier to put transparent, flexible, digitally optimized, and highly competitive production processes into place. ■

During the entire throughput time of over

# 315 h,

the weight of the blank decreases from 13 t to just

# 4 t



Required geometric dimensioning  
and tolerancing is less than

# 0.02 mm



# Large-format high-performance machining

**Technology:** Impellers that weigh tons, tolerances of hundredths of a millimeter — the requirements for producing compressors for the oil and gas industry are becoming more and more exacting. At the Siemens manufacturing plant in Duisburg, Germany, Sinumerik CNCs guarantee the process is flawless right through to the finished part.

The impellers used at the plants  
can have diameters of over

2 m.

There are around 2,400 employees at the Siemens production plant in Duisburg working on the development, production, assembly and approval of gas turbo compressors and on the maintenance of existing customer plants. These plants must be able to withstand temperatures of up to 1,400°C and pressures of up to 300 bar — and do so at speeds as high as 18,000 rpm. Impellers in these plants can weigh several tons and can have diameters of over two meters. Despite their considerable size, the required geometric dimensioning and tolerancing is less than two hundredths of a millimeter. This is because the turbines have to achieve high balancing quality while minimizing the effort required for manual balancing.

These requirements, which are already stringent, are made even tougher by the fact that there are rarely two compressors or more that are identical. There is too much variance in the composition of gases flowing through the compressor and pressures that have to be generated. With very few exceptions, every part is unique in terms of its geometry and the component materials used. This is why just one turbine may call for as many as 235 hours of machining on a single machine. During the entire throughput time of more than 315 hours, the weight of the blank decreases from 13 to just four metric tons.

## The right equipment for every requirement

When a workpiece — especially a one-off piece — meets the high requirements at the end of the process, this is the result of many factors: the expertise of the employees, the 40 CNC-controlled machine tools that contribute to mechanical



accuracy thanks to their geometric precision and kinematics, and the many different Sinumerik control technology solutions used. The current high-performance Sinumerik 840D CNC in particular is able to rapidly process large volumes of data.

The individual steps are carried out quickly and accurately. Options such as the Sinumerik MDynamicS milling package prevent even the smallest unnecessary deceleration and acceleration that would lead to undesirable chatter marks. The exceptionally precise machining achieves the required perfection in surface quality. Sinumerik also has numerous cycles that help turn a virtual workpiece into an actual workpiece; for example, with standards for specific machining operations, support for swiveling operations, and the option of checking machine kinematics during machining directly.

### A process chain with no system change

The dimensions of each turbine blank delivered to Duisburg are determined months ahead of time. A highly efficient and yet time consuming supply chain prevents errors from occurring during production. This is why the delivery time for the blank is the basis for planning and preparing all the necessary machining processes in an integrated CAD/CAM-CNC process chain: NX CAD generates the 3D models, NX CAM turns these into NC programs and, on the machine tool, Sinumerik CNC prevents possible loss of data. Design and development data for specific components are organized in the Teamcenter PLM solution, which serves as a framework for supporting all product and process knowledge.

"This closed digital process chain is one of the things that has enabled us to reduce throughput times from nine to six months," reports Christoph Höhnerbach, head of technology development in Production. The numerous Sinumerik cycles also simplify programming of the parts. These sub-routines are similar to containers programmed for specific movement sequences which can be viewed and simulated during CAM programming. To implement them, parameters only need to be adapted to the specific problem. "We save a lot of time and effort with Sinumerik cycles because complete descriptions or machining operation development are not needed," explains Mario Dewald, team leader in the Digitalization and Operational Support department. He continues: "The post-processor calls up these cycles and processes them cleanly. This applies to all technologies (milling, turning, turn-milling, grinding) and all of the Sinumerik versions we use here."

### Parameterize the cycle and it's ready to go

Numerous cycles are used in Duisburg, for example CYCLE81 for drilling/spot facing. This relatively simple cycle can be used to drill to a defined depth at the programmed spindle speed and feedrate and then retract the tool to its home position. All of the technology cycles mapped in the Sinumerik CNC, such as deep hole drilling, a wide range of counterboring cycles, or drill finishing, can be easily integrated into the programs. Machining operations can



A perfect team: the Waldrich Coburg portal machining center and Sinumerik 840D sl



then be run in a safe and reproducible manner. "It's clear how useful it is to have a cycle for tapping — especially when it comes to parts that need 142 different threads types," emphasizes Mario Dewald.

In addition to cycles that support specific machining processes, CYCLE832 is also used to smooth surfaces during high-speed cutting processes: After the machining strategy (roughing, pre-finishing or finishing) and the tolerances for the machining axes are entered, the respective dynamic parameters are automatically activated to create flawless surfaces at the fastest rate possible.

The CYCLE800 swivel cycle facilitates the machining of complex workpieces in one clamping fixture. It carries out the kinematic conversions and zero offsets necessary for swiveling operations. Swivel functions are available both for swiveling around a machine axis and for swiveling around an axis of the workpiece coordinate system. Any required coordinate transformations are completed automatically by the CNC.

### Consistent monitoring guarantees accuracy

The sometimes enormous sizes of the compressor parts require large machines. That is why a Waldrich Coburg — one of the largest of its kind — is being operated at the Duisburg plant. This Powertec 6000 portal machining center has a machining space measuring 7x8x21 m. The weights that need to be moved and the forces this generates are also enormous. When it comes to machine





Siemens AG / M. Dewald

The Waldrich Coburg Powertec 6000 portal machining center has a machining space measuring

# 7x8x21m

tools of this magnitude, monitoring them using Analyze MyCondition — an application in the Sinumerik Integrate in-line platform — delivers a crucial advantage in planning productivity. This solution can be used to consistently monitor machine tool conditions and identify and prevent conditions which lead to unscheduled downtime.

The CYCLE996 kinematic measurement cycle guarantees that machines of this size maintain the required precision when producing highly accurate workpieces, even during long periods of use. This Sinumerik cycle and the downstream kinematic compensation allow the kinematic accuracy to be monitored or restored at any time — quickly, accurately, and without the need for service personnel or special equipment. Because it runs mostly automatically and comparably little valuable machining time is lost, this function also contributes to productivity. The CYCLE996 throughput can be useful before, for example, clamping a complex workpiece requiring a great deal of machining.

#### **The formula for success: digitalization and the right control system**

In Duisburg, information on how long it actually takes to produce an individual impeller — in terms of productive machine time — comes from the comprehensive operating data acquisition system, to which all the machines on site are connected. The operating data acquisition system answers many questions, including: The door is closed, but is the machine tool running? Is it working productively? Which workpiece is currently being machined? Can this

workpiece be matched to the order it belongs to? A high degree of vertical integration, many product changes, inter-linking and dependencies along the production line — this type of information is becoming increasingly important for maintaining an overview and increasing productivity. Among other areas, this is especially applicable to bottleneck machine tools, which have a major influence on the whole system and output quantity.

Mechanical and process-related developments in machine tools have contributed significantly to gains in productivity. Another key benefit for the future is economically effective utilization and the balance between utilization and capacity. Ongoing processes must be examined in detail and adapted by acquiring data in real time and continuously analyzing process efficiency. Sinumerik control technology and digitalization solutions offer considerable potential in this regard and have enabled the compressor plant in Duisburg to continuously and flexibly adapt to the specific requirements of the demanding oil and gas industry. Over the last few years, this has helped to continuously and steadily increase machining productivity. ■

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# Everything runs smoothly in live production

**Digitalization:** Realistic tests without machines, collisions that cause no damage: this is made possible by virtual commissioning using a digital twin for machines and plants — with flexible Sinumerik Virtual Commissioning Services from Siemens.

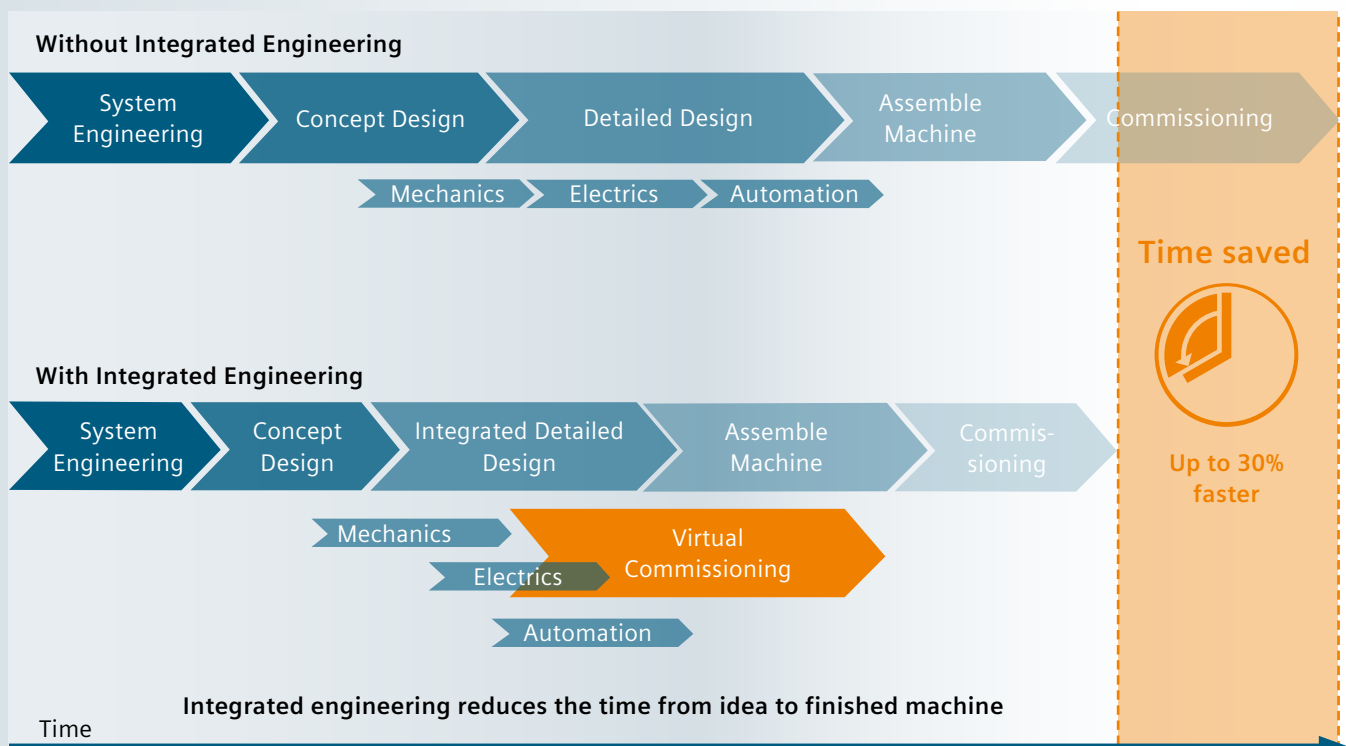
Based in Nersingen, Germany, Maka Systems GmbH develops and manufactures CNC machines for wood, aluminum and plastics machining as well as design modeling. The company has had virtual commissioning of customized plants firmly established in its project management for over a year. Peter Schäch, head of electronics at Maka, sums up the benefits: "Virtual commissioning generates a lot of value for us! That's because the same exact things go wrong in virtual commissioning that would go wrong in

reality — only without the time and cost-related consequences. Collisions can never be completely ruled out. That's why it is so important for collisions to happen on the screen only".

## Starting out in difficult circumstances

Maka took a chance on virtual commissioning at a difficult time: changes to components were jeopardizing meeting narrow schedules for the delivery and installation of a large customized plant for wood working — with eight gantry

axes, six servo-driven conveyor belts, a turning station and complex process logic. The management at Maka hoped to use virtual commissioning to carry out plant assembly and commissioning in parallel, so that the project schedule could be met and the plant delivered on time. Extreme time pressure, a complex plant and the very first experience with virtual commissioning for the Maka team were not ideal conditions for making the project a success. Maka therefore asked Siemens Sinumerik Virtual Commissioning Service for help.



The integrated engineering approach shortens the time spent from development to real commissioning by parallelization. Virtual commissioning reduces the time needed for real commissioning



*Virtual commissioning allowed Maka to save five weeks in their first project.*

#### **A rapid start and a great deal of time saved**

Generally, the technical requirements for virtual commissioning are established quickly. A digital twin is created by scanning the machine's existing CAD data into the Mechatronic Concept Designer (MCD) NX component. After this, kinematic characteristics are also added. Simit is used for "bringing the digital twin to life" via the connection to the CNC control system. This program represents the plant's signal and data interfaces in the computer, and simulates mathematically logical machine behavior. The digital twin's signal states thus correspond to the real plant. Sinumerik CNC is then integrated using Simit's fieldbus emulation, allowing the PLC software to be verified and the NC programs optimized. Every machine reaction is visible on the monitor, and serious errors such as collisions are highlighted by red alerts. Technicians can zoom in on every detail and view what is happening from perspectives that would be impossible in the real plant. Thanks to this approach, Maka was already able to save five weeks in their first project. This outcome was improved even further thanks to other advantages: travel time was reduced,

damage from potential errors was avoided — and all specialists were available to the company.

#### **A step-by-step process and rapid learning**

Sinumerik Virtual Commissioning Services from Siemens are tailored to the specific customer and project. This allows machine tool builders to minimize risks, reduce costs and shorten project durations. The team also quickly learns how to use new technology. During their first project, Maka made use of the Siemens Sinumerik Virtual Commissioning Services in many preparatory phases — transfer of CAD data, kinematic modeling, parameterization, etc. "It is advisable to follow this step-by-step process in real projects. The technical requirements are quickly established, the processes learned, and the employees come to grips with things quickly. Pretty soon they no longer need any outside help," explains Gerd Müller, Technical Sales Support at Siemens. Maka employees are now well trained in using the software tools. There are digital twins for many plant components which can be quickly and easily expanded on a project-specific basis.

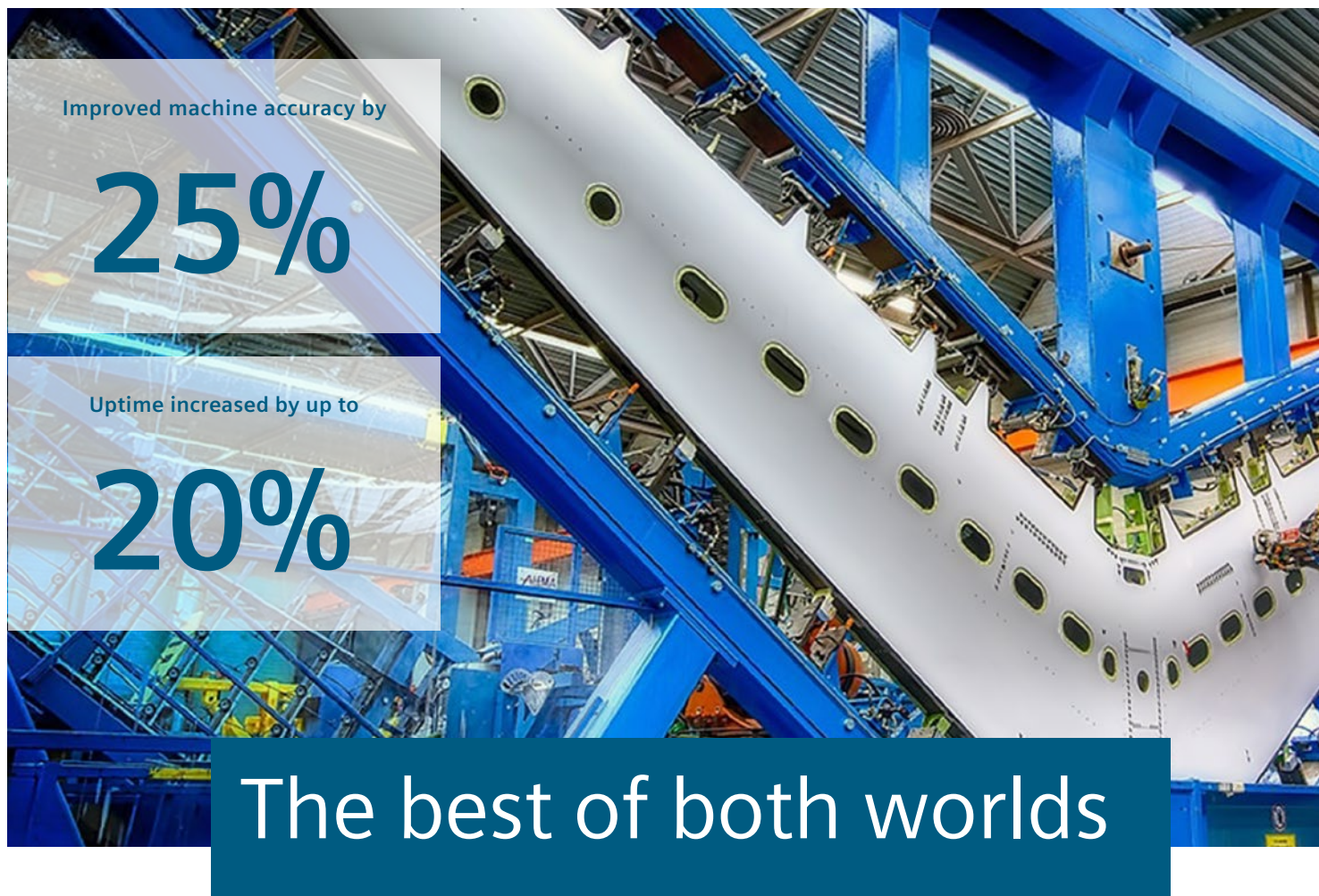
#### **One application leads to another**

"Once companies have had their first experience with a digital twin, they usually discover other potential uses for the technology, such as in service and maintenance. Whether it's malfunctions, planned expansions or automation — everything can be analyzed and simulated using the digital twin. We also have customers who use the digital twins in marketing," adds Müller.

Consulting, tools, services, and training for virtual commissioning: Siemens provides machine tool builders with flexible and complete solutions that pay for themselves quickly and sustainably. At Maka, all virtual commissioning of customized plants is now done within the company. However, what all these projects have in common is the excitement when a plant runs fault-free directly after the mechanical and electrical components have been set up. ■

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**Automation:** To enhance production, tool management, and its ERP interface, GKN Aerospace Monitor utilizes a Sinumerik 828D CNC while continuing to use older drives and components.

In a classic “best of both worlds” scenario, Amityville, New York-based GKN Aerospace Monitor retrofitted a Cincinnati Milacron 3-axis Hydrotel milling machine, replacing the old Acramatic CNC with a new Sinumerik 828D, a mid-range control designed specifically for such machine tools. In this project, a team consisting of facility manager Bob Morandi and director of facilities and machine maintenance Chris Nagowski at the leading aerospace component manufacturer turned to its longtime retrofit partner, Control System Innovators (CSI) of Rochester Hills, Michigan, for a solution that would accomplish three goals: improve the control scheme on

the 3-axis machine tool, preserve the old Ghetys DC servo drives plus spindle motor, and achieve improved surface finish on the parts, most of which are used in aircraft structures.

#### **Cost-efficient retrofit with higher-level control**

On the existing machine, which dates back to 1972, the control had become old and obsolete because replacement parts and repair service were no longer available. According to GKN, software support was no longer provided either. Additionally, with no ability to track production time or even cycle time, the old CNC machine was becoming a drain on the main-

tenance department, and was frequently out of service. Tool use was also not tracked and the situation simply became untenable. A.J. Rosewarne, senior applications engineer at CSI, commented on the project. “In addition to the control upgrade, the customer wanted integration into their tool network, and so we needed to work with the IT team at GKN as well as the machine group.” He explained that a company-wide tool database is maintained on the network system at the facility. On the new control, a thin client PC finds the tool info station and delivers the correct parameters to the machine.



GKN in Amityville produces parts that are typically used in aircraft construction

GKN Aerospace

division of Siemens Industry US added, "This new Sinumerik CNC gives the customer a full protocol for OEE (overall equipment effectiveness), another goal at GKN. For a relatively low-cost retrofit, there were significant benefits delivered to this end-customer as a result of the higher-level control." The CNC on the machine also offers a look-ahead feature. Depending on the substrate, this helps achieve substantial improvements in surface finish.

#### Integrated tool management

As a direct result of this upgrade to a Sinumerik 828D CNC, GKN confirms that they have achieved greater reliability, and increased uptime on the machine by up to 20%. In addition, the tool management integration has brought the machine into compliance with company standard and, finally, through the CNC the company now has a networking system for program management, connecting all machines in the facility. With all data being tracked on the machine, OEE calculations became possible, as well. Maintenance reductions have already been tracked on the Cincinnati machine since this retrofit was performed by CSI. Anjali Awasthy, lead software architect at GKN, commented on the control. "We wanted to integrate the new Sinumerik 828D with our tool management system, so we amended our tool change routines to automatically update the tool

parameters from our ERP system for the active tool at the appropriate run time. Additionally, collaboration between the IT and operations personnel allowed us to use RFID-enabled tools and validate tool likeness on the multi-spindle machine controlled by the Sinumerik CNC. To a large extent, we are able to use the 828D as we do its 'big brother,' the 840D, which we have on many other machines at GKN." Nagowski added, "Downtime on the machine has been completely eliminated and scrap parts due to CNC issues have gone from an average of seven pieces per year to zero. Machine accuracy has improved by 25% thanks to the digital encoder feedback replacing the Position Analog Unit and bi-directional pitch error compensation."

#### Improved machine performance

From the GKN perspective, the job went according to plan. Nagowski commented, "Our proprietary Shop Station software development has been a driving factor at GKN. We want all machines online with it." He noted the results of the retrofit ensure better control of program software, less manual intervention, and enhanced tool management for the company. Nagowski also observed that the accuracy of the machine has actually increased. This often happens on retrofits of older machines, frequently beyond original specifications, owing to the digital feedback encoders supplied with modern control technology. Finally, he indicated that GKN is planning other retrofits of similar Cincinnati machines in the near future.

"You might say we're controlling our future, here at GKN," Nagowski muses. In the end, the improvement in machine performance, overall plant-wide data management, and personnel utilization makes that statement quite accurate. "By investing in the Siemens control, we're seeing a greater return on our CNC investment — a better return from our machines, our operations, and even our people. ■

Rosewarne said it took a week to do the mechanical and electrical engineering and another two weeks to perform the installation and commissioning, teaming up with the GKN team on the installation. Project costs were reduced by retaining the DC drives, hardware panel, and even some of the I/O modules. In summary, Rosewarne said thin client PCs have factory-wide access to the tool database based on remote network storage on the drive, which is accessed via the HLA module in combination with the CNC communication port, thus bringing the machine up to GKN company standards. Rob Stiefel, account manager with the Aerospace



The new Sinumerik 828D at GKN offers modern control technology

GKN Aerospace

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# High-precision manufacturing for the aviation industry

**Automation:** Chester Hall Precision is renowned as a leading supplier of aerospace components. The company relies on Mazak machine tools with Siemens CNCs for manufacturing high-precision aircraft parts.

Founded in 1974, Chester Hall Precision Engineering Ltd. has its headquarters in Wickford, Essex in England. More than 100 employees work for the company in three shifts. This means from Monday to Friday production takes place around the clock. Chester Hall formerly produced components for sectors such as the defense and automotive industries. Today, the company manufactures high-precision parts, modules and sub-assemblies from various metal alloys for the aerospace industry. Chester Hall also offers all-in service with concurrent engineering, manufacturing, treatments, assembly, and full supply chain management.

## Success founded on continuous improvement

"Most importantly for our success, we hold all relevant BSI accreditations, and have recently gone through our BSI recertification audit for the BSI AS9100 Rev D, which is the new BSI revision standard speci-

fically relating to aerospace companies. It's an achievement to be accredited to these stringent standards, but it is vital for what we do, namely critical, large structural components for aircraft," says Phil Brown, director at Chester Hall Precision. He describes how extremely exacting the aerospace industry is: "It is a very demanding sector, with the main challenges being product quality, and OTD, or 'on-time-delivery.' It is also very competitive, so you have to keep up with the latest technology or someone will overtake you."

Brown believes that the key to Chester Hall's success has been putting in place a continuous improvement culture. The company thus operates on the "first time right" principle. At Chester Hall, this entails the off-line programming of 5-axis machining centers, state-of-the-art machining simulation software, a lessons-learned methodology

and stringent internal audits, data analysis, and training programs. The result is that the company has developed long-term contractual partnerships with "Tier 1" aerospace manufacturers.

## Chester Hall, Mazak and Siemens: a winning team

Because Chester Hall recognized the significance of CNC machines at an early stage, the company began working together with Japanese machine tool builders Mazak in 1995. "Our business relationship with Mazak is very important to us," explains Brown. "Our first machines were equipped with Mazatrol, but as we developed our capabilities we increasingly standardized on Siemens control systems, which are very user-friendly. Our setters and operators really appreciate that they are more Windows — based, so it feels like you are on a PC, which means people get to grips with it quite quickly."





*»The fact that we can now get VTC-800 series machines with a Sinumerik control, which we've all but standardized upon, made the decision an easy one.«*

Phil Brown, Managing Director, Chester Hall

Chester Hall now has a total of eight Mazak machines, including two FH-880 and FH-8800 horizontal machining centers and four VTC-800 series machines that are operating around the clock. "We like the VTC-800 series. It's a powerful machine equipped with a good fifth-axis movement that allows the spindle head to rotate a full +/- 110°. The fact that we can now get VTC-800 series machines with a Sinumerik control, which we've all but standardized upon, made the decision an easy one," says Brown in summary.

#### **A good partnership for that special customer service**

Chester Hall produces high-quality components on its VTC-800 series machines. However, in the demanding aerospace sector after-sales support is almost as important as the quality of the products. "With machine tools, the main challenges are support, repeatability, reliability and OEE or 'overall equipment effectiveness.' We need a machine tool partner who is ultra-responsive," says Phil Brown and adds: "We are demanding because our customers are demanding, but we appreciate that Mazak knows that if something goes wrong, we need it sorted out as soon as possible."

#### **A worthwhile investment**

Brown believes that further investments in technology and people will be the key to maintaining success: "I can see us making further machine investments, probably with more VTC-800 capacity." ■

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Published by  
© Siemens AG 2018

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Article No.: DFMC-M10052-00-7600  
Printed in Germany

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