HEXAGON

Solution brochure

Machine shop solutions

Creating end-to-end smart manufacturing workflows for the machine shop

Competing in a challenging market

Machine shops typically manufacture components and assemblies based on the design provided by their customers. Machine shops typically belong to tier 1, tier 2 and tier 3 suppliers of OEMs and serve various industry verticals including automotive, aerospace, industrial equipment, electronics, oil and gas, medical and consumer products. The key challenges faced by machine shops are:

- Optimising raw material cost
- Optimising manufacturing cycle times
- Accommodating changes in design from the customer
- Ensuring first time right manufacture every time and minimising rejection and rework
- Ensuring smooth execution of manufacturing activities to meet the delivery date for the end customer
- Ensuring the quality of the finished product irrespective of operators' skill levels
- Optimising the overall product and project cost

Hexagon's machine shop solutions address these challenges at each stage of the workflow from enquiry to dispatch using a smart manufacturing approach based on various Hexagon products.

Smart manufacturing workflow

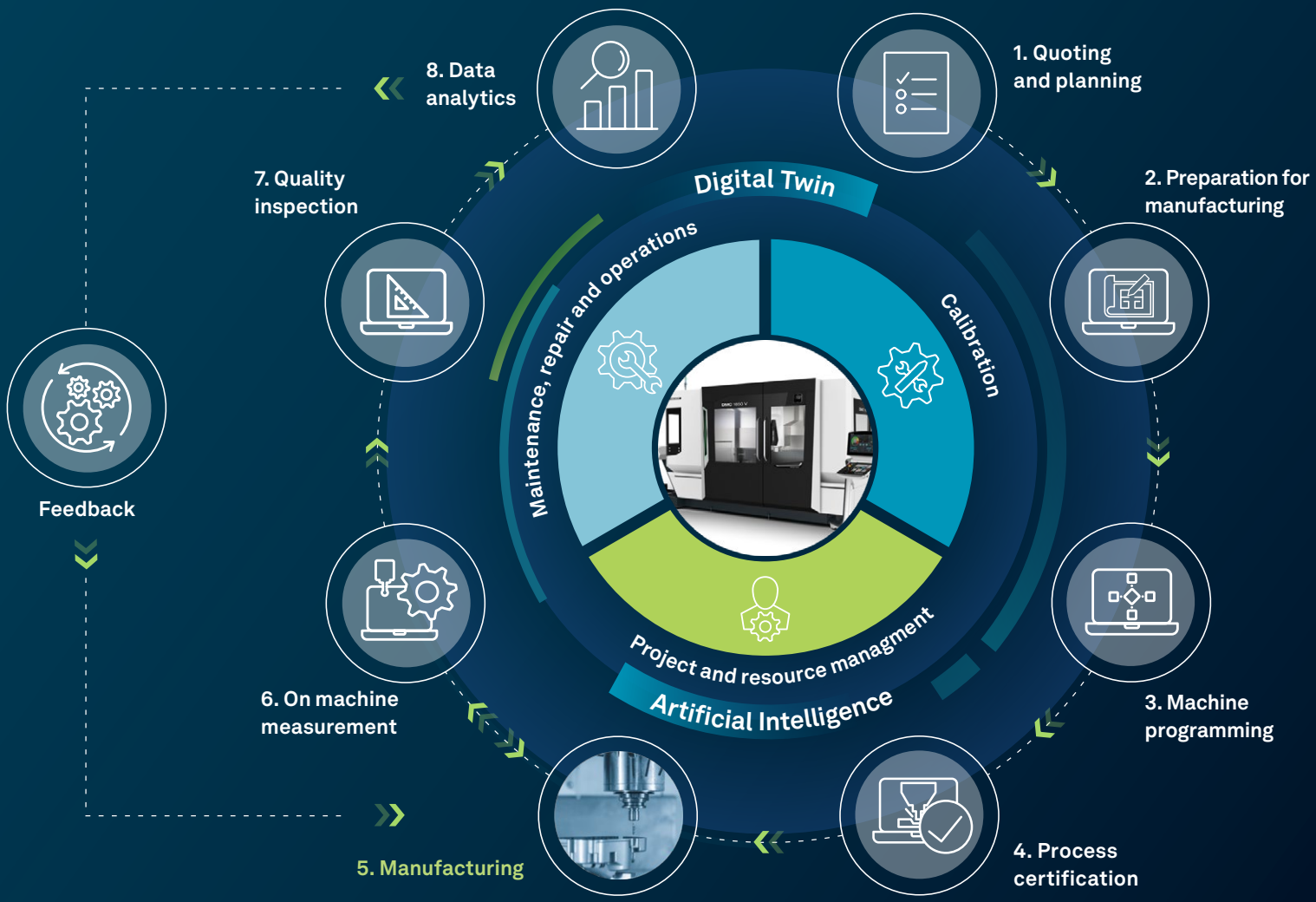
The smart manufacturing workflow for a machine shop involves several stages:

1. Planning and quoting
2. Preparation for manufacturing
3. Machine programming
4. Process certification
5. Manufacturing
6. On-machine measurement
7. Quality inspection
8. Data analytics
9. Feedback to manufacturing

This sequential process is supported by ongoing activities and enabling technologies throughout:

1. Digital twin and artificial intelligence
2. Machine and equipment calibration
3. Resource management
4. Maintenance repair and operations

Machine shop solutions



Machine shop solutions

Smart manufacturing workflow

Quoting and planning

Perparation for manufacturing

Machine programming

Process certification

Manufacturing

Digital twin and artificial intelligence

Sequential manufacturing process and related products

Project specific manufacturing
- WORKPLAN

Sheet metal
- Radquote
- FormingSuite

Mould and die
- VISI

All
- DESIGNER
- WORKXPLORE
- REcreate

Mould and die
- VISI, WORKNC, SMIRT

Production machining
- EDGECAM, ESPRIT, CAM, SURFCAM

Sheet metal - RADAN

Wood and stone
- ALPHACAM, CABINET, VISION

Dental - WORKNC DENTAL

Additive - ESPRIT Additive

All
- NextGen CAM products, ESPRIT TNG, SFx TMS

Mould and die
- NCSIMUL

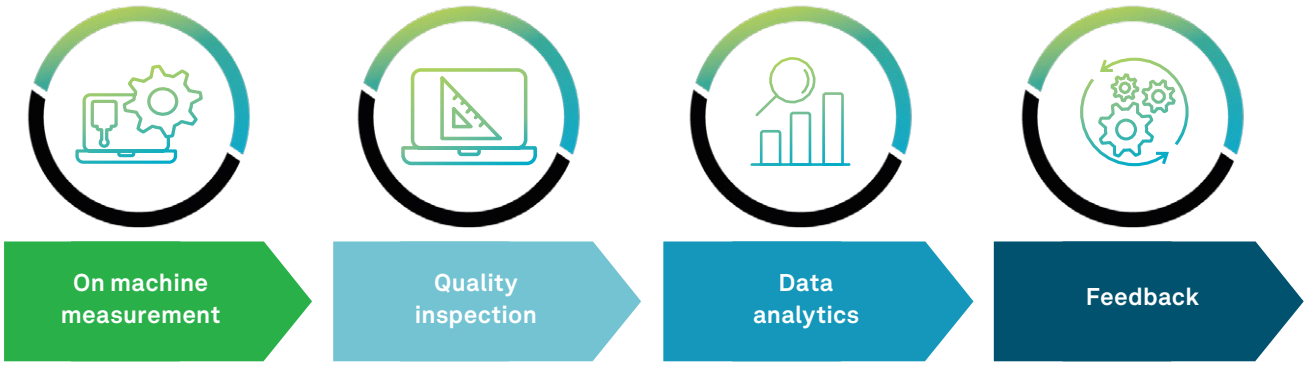
Production machining
- NCSIMUL

All
- Simufact

All (not Hexagon's scope)
- Machine tools
- Cutting tools
- Fixtures / accessories

Machine shop solutions

Smart manufacturing workflow



Digital twin and artificial intelligence

Sequential manufacturing process and related products

Mould and die
- Machine tool probes
- NC Gage
- PC-DMIS NC
- Laser scanner

Production machining
- Machine tool probes
- NC Gage
- PC-DMIS NC
- Laser scanner
- EDGECAM Inspect

All
- Metrology hardware and software

All
- Q-DAS software

Production machining
- Q-DAS IMC

Calibration

Project and resource managment

Maintenance, repair and operations

Ongoing process and related products

Mould and die
- Etalon

Production machining
- Etalon

All
- WORKPLAN
- FASYS
- SFx Assest Management

All
- InforEAM

1 Quoting and planning

During this stage, a quotation is prepared considering various types of costs involved, such as material costs and manufacturing operations costs. Overall process planning is completed considering the various stages from enquiry to dispatch.

Hexagon's WORKPLAN manufacturing project management platform provides users with the ability to manage the entire workflow, starting with the product enquiry all the way through to dispatch.

WORKPLAN can create a quotation for a particular opportunity. It also has an interface with the Radquote sheet metal quotation program, which enables quick and easy quote creation for sheet metal parts and purchased parts. It gives a full breakdown of the costs and allows each cost area to be altered to give flexibility when negotiating.

WORKPLAN schedules projects and jobs based on set priorities and resource availability. It supports forward-looking project planning. Manufacturers can use WORKPLAN's Gantt charts to optimise workload, reduce bottlenecks, control milestones and meet due dates.

WORKPLAN includes an easy-to-use drag and drop graphical tool to set routing order and create workflows. These workflows can be simulated for a set period, based on project due dates. Users can also set various internal due dates to ensure tighter management and provide a buffer in the workflow. WORKPLAN automatically generates a resource load planning schedule, which considers available capacity.

Using WORKPLAN, various manufacturing activities can be planned and scheduled, resources optimised, and progress tracked against the plan to ensure that the project is delivered on time as per the customer requirement.

Hexagon's FormingSuite solution employs cost engineering principles to determine raw material and tooling costs, plan the production process, and evaluate the manufacturing feasibility of sheet metal components at a very early stage during product definition, based only on the part geometry.

2 Preparation for manufacturing

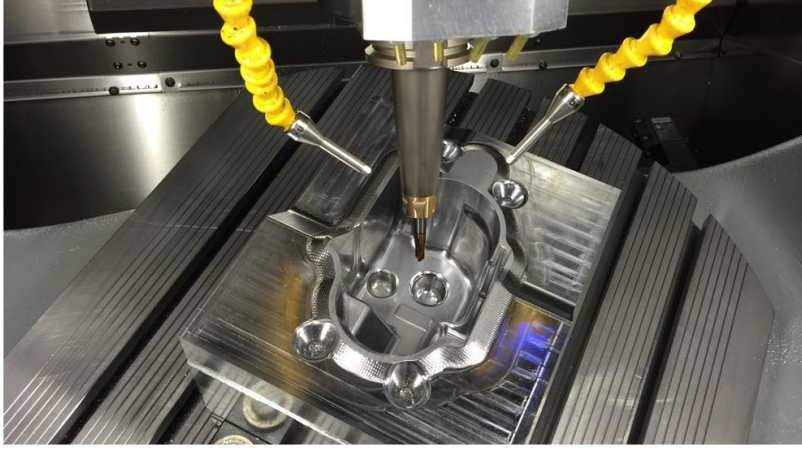
During this stage, technical input from the customer, such as model files, are validated for manufacturing feasibility and the model prepared for manufacturing to ensure smooth execution of manufacturing operations. Hexagon products such as DESIGNER, REcreate, VISI Analysis and WORKXPLORE support users during this preparatory stage.

DESIGNER is Hexagon's CAD application for smarter manufacturing and provides a variety of solid, surface and sheet metal modelling capabilities, creation of 2D drawings, electrode design, design automation through macros and scripting, and a link to Hexagon CAM software and reverse engineering functionalities.

Using VISI Analysis, users can validate and prepare the model geometry, finding potential problems at an early stage within the project that greatly simplify the task of the mould designer and generate huge time savings during the mould design process.

REcreate is a dedicated reverse engineering software that reduces workflow complexity to create a faster and more flexible design, production and inspection environment.

WORKXPLORE is a powerful, full-featured, high-speed CAD file viewer and analyser. It is specifically developed to increase collaboration, productivity and effectiveness throughout cross-functional product development activities including design, process development, manufacturing, quality, sales, and customer communication, purchasing and product documentation.

3 Machine programming

During this stage, CAM programming is completed in CAM software, using various relevant machining strategies considering the raw material stock, tooling, fixtures and the machine tool.

Hexagon's CAM applications address the growing challenges of achieving manufacturing efficiencies while delivering significant value to the operations for the production machining, mould and die, sheet metal fabrication, stone and woodworking industries. Hexagon provides a range of segment-specific CAM software solutions for CNC machine programming:

Production machining

- ESPRIT® is a high-performance CAM system that significantly improves machine tool productivity in even the most demanding production machining applications.
- EDGECAM is a market-leading production CAM solution, combining the power of sophisticated toolpath generation with seamless CAD integration.

Mould and die

- WORKNC is the leading high-end CAM software solution for complex models in the mould, die and tooling industries for 2 to 5-axis CNC programming.
- VISI is a CAD CAM solution for the mould and die industries offering 3D tool design, plastic flow analysis, sheet metal stamping and comprehensive multi-axis milling strategies.

Sheet metal fabrication

- RADAN is the world's leading CAD CAM solution for the sheet metal cutting industry, providing applications for punching, profiling, bending, design and production management.

Woodworking

- ALPHACAM is the CAM software of choice for the routing and stone cutting industries. The software portfolio provides customers with proven technology to increase productivity.
- CABINET VISION is a complete engineering solution for the case good industry, right from entry-level cut list packages to fully integrated solutions.

4 Process certification

During this stage, the machining process is simulated by creating a digital twin of the machine tool along with required tooling and fixtures to verify and optimise the toolpath generated, ensuring that there are no collisions and thereby certifying the manufacturing process.

NCSIMUL manages the complete machining process from the NC program to the machined part. Its capabilities allow users to fully master the shop floor and include automatic G-code reprogramming and G-code simulation. NCSIMUL virtually builds the real-life machining environment to eliminate errors, decrease setup times, reduce manufacturing costs and increase shop floor productivity.

NCSIMUL Machine is a high-end CNC simulation software for G-code verification, machine simulation and tool optimisation. It detects programming errors and any potential collisions from the same NC code that drives the CNC machine.

NCSIMUL Optitool analyses cutting conditions, dramatically reduces 'air cutting', optimises feed rates and allows users to create better cutting strategies. The overall benefits are a reduction in production cycle times, enhancement of cutting operations and fast development of new G-code optimised files for future applications. This module allows users to optimise the tool lengths, air cutting and cutting conditions of NC programs (from 3- to 5-axis simulation software) and globally increase the quality of machining operations.

Simufact simulation products offer specialised design and optimisation tools for specific manufacturing processes: Simufact Forming for forming simulations, Simufact Welding for welding simulations, and Simufact Additive for additive manufacturing.

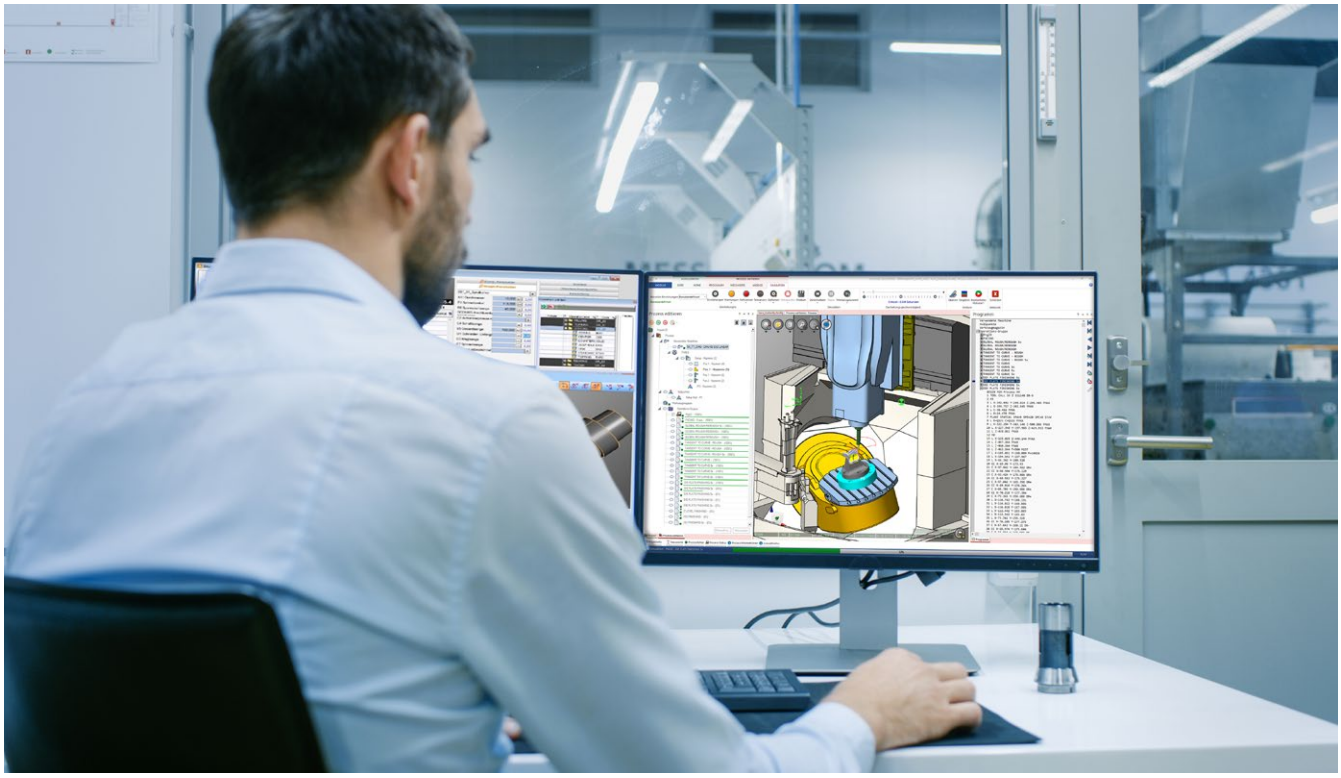
Simufact Forming's Sheet Metal Forming module is used to simulate the forming of sheet metal parts from flat-rolled pre-materials. This module supports the manufacturing of tubes, profile parts, structural parts, engine and transmission housings, mechanical components, electronic

parts such as connectors, and many other products. It supports transfer presses as well as progressive dies, roll forming and roll production processes.

Simufact Forming's Mechanical Joining module is designed specifically for the simulation of mechanical joining processes. It allows the numerical computation of technologies primarily based on joining-based forming. Various riveting procedures, such as punch riveting, self-piercing riveting or blind riveting, can be analysed.

Simufact Welding is used for modelling and optimising a wide range of thermal joining processes, considering weld sequence and clamping. Processes such as arc welding, laser beam welding, electron beam welding, brazing and resistance spot welding can be modelled.

Simufact Additive is a scalable software solution for the simulation of metal-based additive manufacturing processes. It is designed to predict and compensate for distortion and helps to minimise residual stress and homogenise temperature distribution throughout the entire AM process chain before the part is manufactured by the 3D metal printer.



5 Manufacturing

During the manufacturing stage, the raw material stock is machined or sheet metal is fabricated on CNC machines with a given set of tools, fixtures and accessories. Machining operations for mould and die and production machining typically involve turning, milling, turn-mill and multi-axis machining. Sheet metal fabrication operations involve punching, laser cutting, bending, forming, nesting and welding, amongst other processes.

6 On machine measurement

During this stage, measurements are taken for the part produced on the machine and feedback is provided comparing the results of the measurement with the actual required dimensions for the part.

EDGECAM Inspect combines Hexagon's industry leading metrology tools and expertise with cutting-edge manufacturing expertise. It is a full featured, easy-to-use solution for users looking for fast creation of on machine measurement cycles with quick, efficient tool path creation and generation of reliable, measurement results. It offers unparalleled ease-of-use and sophisticated probe path generation for both in process and end item part inspections.

NC Server connects the power of PC-DMIS measurement software to CAM Software and machine tools, pairing unmatched measurement capabilities with 24/7 automation and feedback functionality in a dashboard that actively monitors the status of the measurements over multiple machine tools.

- From simple to complex inspection tasks, Hexagon software can be used for all static path inspection tasks
- Complete reporting and analysis capabilities

NC Server provides edit-free, integrated manufacturing and inspection NC-Code:

- Create on-machine inspection G-code with EDGECAM, directly integrated with the machining code
- Clear CNC code that can be understood by the operator
- Simulate in EDGECAM or in NCSIMUL
- CNC files can be stored on internal DNC or managed in NC Server

7 Quality inspection

During this stage, final inspection is done for the part produced using various metrology hardware devices and software to ensure the required quality of the product.

From hand tools to automated solutions, coordinate measuring machines (CMMs) to portable measuring arms, laser trackers and optical scanners, Hexagon provides industrial metrology systems for when dimensional measurement matters as a part of quality inspection process.

Coordinate measuring machines (CMM)

From entry-level to ultra-high accuracy and shop-floor optimised, Hexagon's unparalleled CMM range drives quality and productivity for manufacturers.

Multisensor and optical CMMs

Multisensor CMMs deliver unparalleled flexibility by deploying the precision of tactile probing and the high-speed measuring point capture of non-contact measurement on a single system and within a single measurement run, making it simpler and faster to measure even the most complex parts.

Large volume CMMs

The largest gantry and horizontal arm CMMs require robust materials, a stable structure and high accuracy, whether on the production floor, in a production cell or in the measuring room.

Laser tracker systems

Laser tracker systems lead the field in terms of the accuracy, reliability and durability of portable coordinate measuring machines.

Portable measuring arms

Portable measuring arms allow quick and easy measurements directly in the manufacturing environment, where process improvements are the most beneficial.

Structured light scanners

Structured light scanner systems are comprehensive 3D optical measurement solutions that deliver high-accuracy data capture at high-speed for small-to-medium sized parts.

Industrial 3D laser scanners

Laser scanners play a key role in quality assurance. 3D digital capture of shapes and surfaces using lasers is an effortless and precise process. The industry uses laser scanners primarily for the quality control of geometries and surface, but also for reverse engineering, fit and finish, and assembly applications.

Tube and wire inspection solutions

Hexagon's comprehensive range of tube and wire measurement systems delivers solutions tailored to a variety of applications in tube production.

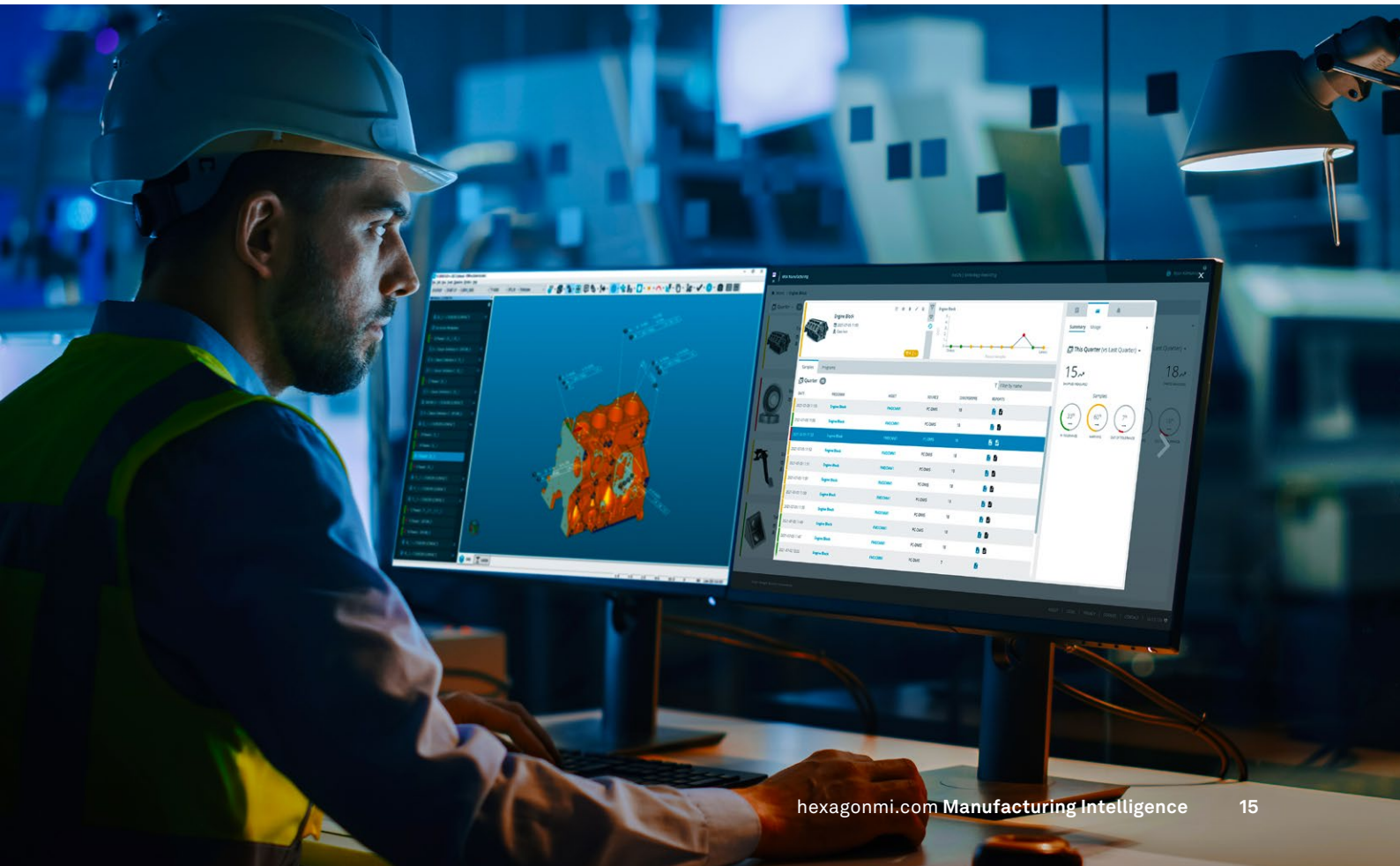
Hexagon also offers a wide range of in-house developed, individually customisable software packages that deliver intelligent and effective data acquisition, analysis and evaluation as well as powerful data management and reporting tools.

CMM inspection software

PC-DMIS can be the single metrology software solution across the shop floor. It is flexible, scalable, powerful and compatible with all kinds of metrology devices.

Portable scanning and inspection software

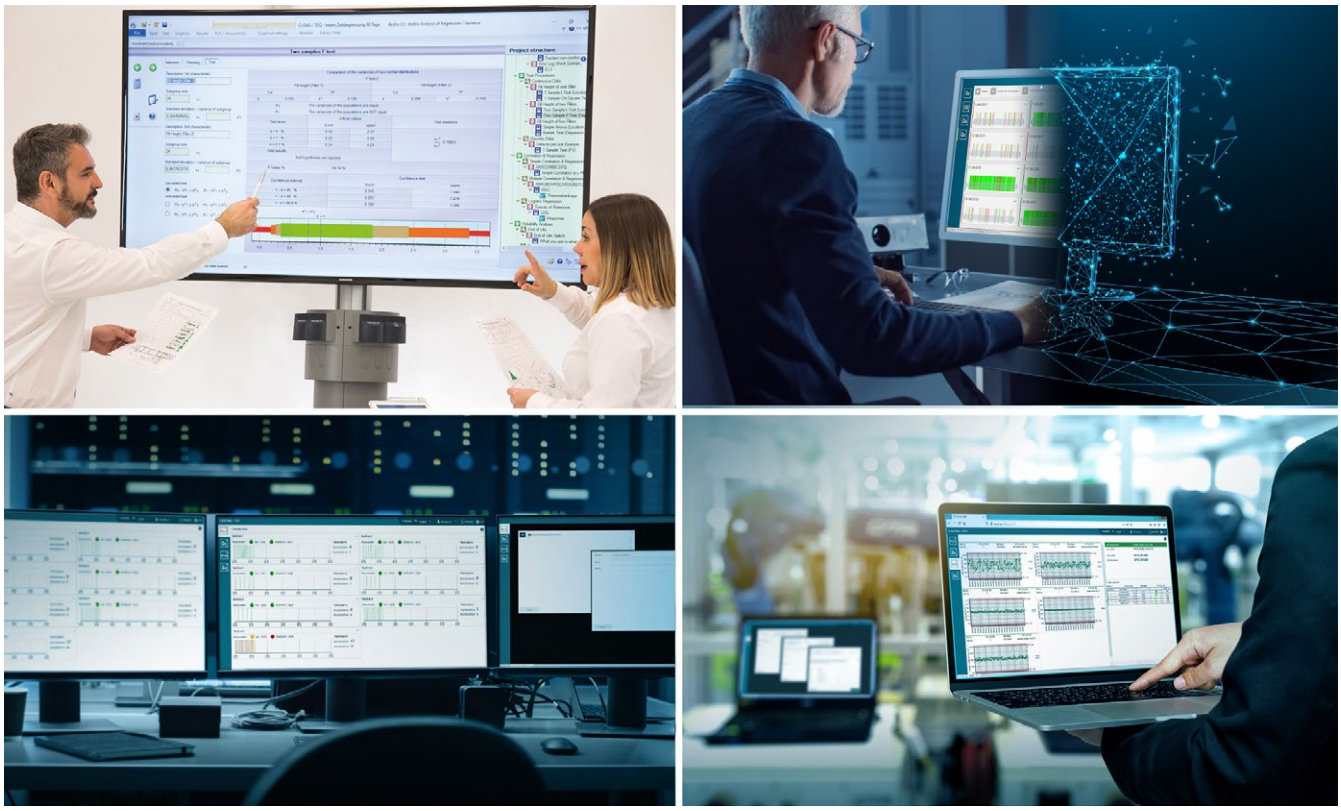
Whether scanning or probing with a portable arm or using a laser tracker, small or large-scale applications, Inspire and SpatialAnalyzer offer state-of-the-art inspection solutions.



8 Data analytics

Reliable quality data is a vital tool for process evaluation and control. The Q-DAS process control and analytics range from Hexagon provides software services for the efficient and reliable application of the statistical methods needed to set up a quality ratio system in industrial production. The portfolio offers:

- Quality data management
- Data acquisition and statistical process control on the shop floor to quality reports and dashboards on the top floor
- Reporting based on industry standards, norms and guidelines
- General production quality monitoring and dashboard tool
- Complete quality solutions
- Predefined evaluation strategies to ensure best practice
- Automation of data flow, data analysis and visualisation
- Modular and flexible offerings to align with customer requirements



9 Feedback to manufacturing

During this stage, based on advanced analysis of statistical data collected through various measurements for the parts produced, feedback is provided to correct the manufacturing process, if needed. Hexagon's Intelligent Machine Control (IMC) solution enables an automatic feedback loop for production.

- IMC automates the calculation and execution of tool offset corrections to help optimise production processes
- Using advanced statistical analysis of measurement data, IMC improves the dimensional quality of all features produced with a specific tool
- This in turn has a significant impact on the reduction of scrap parts and in increasing overall productivity

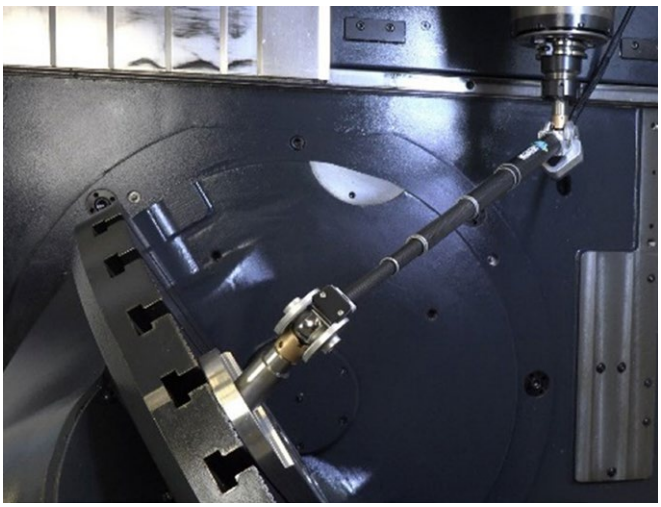
10 Machine and equipment calibration

Machine tools and metrology devices need to be calibrated at their recommended standard frequency to ensure consistency in manufacturing and quality control processes.

Hexagon's ETALON machine calibration systems use multilateration, a spatial measurement technique deployed by satellite navigation systems, to increase measurement speeds and ensure the highest levels of accuracy when calibrating, compensating and verifying machine tools and other industrial equipment. The speed and precision of multilateration means manufacturers can reduce measurement times by up to 80% compared to conventional laser interferometers, securing results in one to two hours instead of one to two days.

The ETALON LASERTRACER-NG simplifies the calibration and monitoring of coordinate measuring machines (CMMs) and machine tools to offer unrivalled accuracy and cost-effectiveness.

ETALON TRAC-CAL | TRAC-CHECK patented software helps to reduce the time spent on ensuring machine tools meet key international standards for precision. It uses a single self-tracking laser interferometer to make measurements more accurate and traceable, while reducing maintenance and recalibration costs.



11 Resource management

It is important to monitor resources such as machine tools, CMMs and tooling in real time to ensure maximum utilisation as a part of the optimisation of the overall manufacturing process.

HxGN SFx | Asset Management

Hexagon's solution for industrial IoT device monitoring enables manufacturers to monitor the performance, availability and health of manufacturing assets through Hexagon's SFx platform. It is a real-time monitoring solution for CNC machines and CMMs and supports asset tracking to analyse performance and improve overall equipment effectiveness (OEE).

SFx Asset Management is designed to maximise overall equipment effectiveness (OEE) and operational excellence indicators, either for a single device or for a set of systems, whether in real time or reporting over a period of time.The solution offers data and metrics including:

- Real-time asset dashboard showing machine status
- Real-time notifications of critical events
- Real-time and historic event logging
- Availability = Operating time / Scheduled time
- Performance = (Programs executed x Ideal execution time) / Operating time
- Quality = Programs successfully executed / Total programs executed
- Quality = Acceptable jobs / Total jobs done

FASYS

FASYS provides efficient tool and operational resource management. Key capabilities include:

- 2D/3D tool and resource management based on industry standards
- Central data management with interfaces to major CAD/CAM systems and leading PLM/ERP systems
- Integration of tool storage, pre-setting and assembly data
- DNC solution for all conventional CNC control units and pre-setting devices
- Inventory management with integrated ordering and connection to storage systems or dispensers

12 Maintenance and repair operations

It is important to proactively manage the maintenance of industrial equipment to achieve better operational efficiency and optimise maintenance costs.

The Infor® EAM solution from Hexagon digitalises maintenance with built-in industry-specific capabilities for manufacturing. It helps organisations manage, track and analyse maintenance activities. Native mobile applications significantly improve field efficiency, providing the team with time to focus on more strategic initiatives. Key capabilities of the solution include:

- Proactive management of maintenance actions to ensure control
- Anticipation of preventive actions for efficiency improvements
- Control of maintenance budgets to optimise profitability
- Measurement and evaluation to make informed decisions

Maintenance repair and operations (MR&O)

Manage, track and analyse your maintenace activities with dedicated software

Management

Pro-actively manage your maintenance actions and keep control

Planning

Anticipate your preventive actions and improve your efficiencies

Budget

Control your maintenance budget and optimise profitability

Analytics

Measure and evalute to make informed decisions

MR&O by Hexagon

Optimise efficiencies to increase the bottom line

Manage assets

- Single source of data
- Extend asset lifecycles
- Improve capital expenditure planning
- Track costs and history
- Maintain knowledge base
- Track asset documentation

Reduce downtime

- Work order planning
- Preventative maintenance
- Automated alerts
- Optimize inventory on hand

Optimise operational efficiencies

- Anazlyse trends
- Track asset performance
- Increase “Wrench time”
- Minimise non-compliance and safety issuses

Overall key benefits

Hexagon's machine shop solutions provide key benefits including:

Optimisation of raw material

Optimisation of manufacturing cycle times

Better resource utilisation for equipment and operators

Integrated workflow for ease of use and faster training

Minimisation of rejection and rework during manufacturing through feedback loop

Better control over the quality of the product

Optimisation of overall product and project cost

Faster time to market, ensuring on-time deliveries to the end customer

Hexagon is a global leader in digital reality solutions, combining sensor, software and autonomous technologies. We are putting data to work to boost efficiency, productivity, quality and safety across industrial, manufacturing, infrastructure, public sector, and mobility applications.

Our technologies are shaping production and people-related ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

Hexagon's Manufacturing Intelligence division provides solutions that use data from design and engineering, production and metrology to make manufacturing smarter. For more information, visit hexagonmi.com.

Learn more about Hexagon (Nasdaq Stockholm: HEXA B) at hexagon.com and follow us @HexagonAB.

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