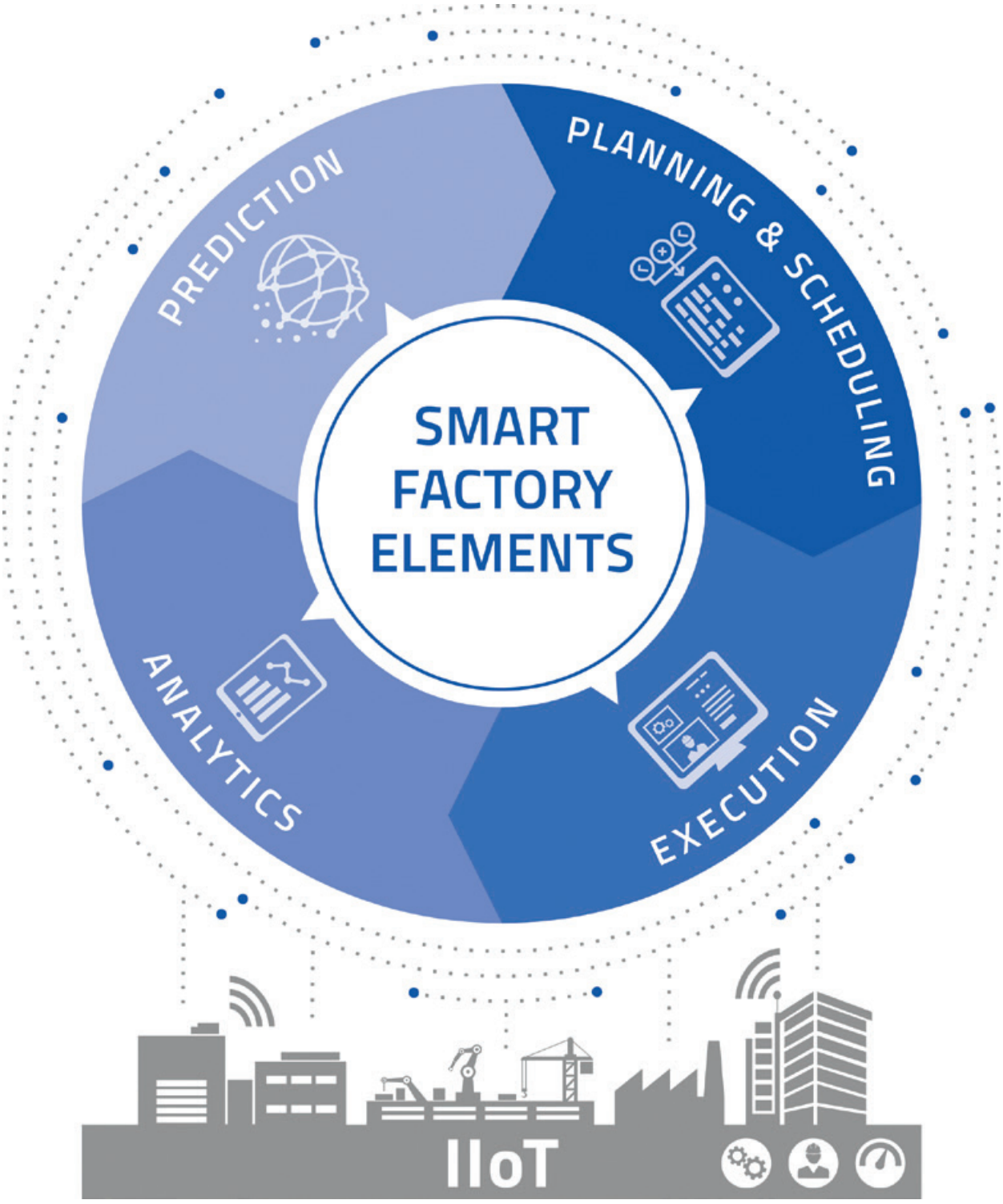
White paper | June 2021

WE CREATE SMART FACTORIES

A model for the innovative production IT

Smart Factory Elements


PREDICTION
PLANNING & SCHEDULING
SMART FACTORY ELEMENTS
ANALYTICS
EXECUTION
IIoT

A model for the innovative production IT

Smart Factory Elements

The challenges facing production have grown enormously and are leading to increased complexities like a high product diversity, short delivery times, fast process changes, smaller batch sizes up to batch size 1. In times of Industry 4.0, this is clearly a case for the Smart Factory - which in turn needs certain processes, applications and functions meet the growing demands: the Smart Factory Elements.

Based on many years of market experience, we are presenting a model with five elements, each combining a multitude of functions and applications: Planning & Scheduling, Execution, Analytics, Prediction and Industrial Internet of Things (IIoT). The applications of these Smart Factory Elements make the vision of Industry 4.0 a reality and enable manufacturing companies to produce competitively even under complex conditions.

The functional range of a modern Manufacturing Execution System (MES) covers even today a large amount of tasks that are described in this white paper. However, new methods and tools (e.g. artificial intelligence) are also needed, especially for „Analytics" and „Prediction", to generate further information and predictions from the existing data. While the MES HYDRA X and the Advanced Planning and Scheduling System (APS) FEDRA from MPDV already offer significantly more functions than a classic MES, there is still ample room in the „Smart Factory Elements" model for applications contributed by suppliers from the Manufacturing Integration Platform (MIP) ecosystem.

Control loop of the Smart Factory

The control loop according to the „Smart Factory Elements" model envisages that production is planned (Planning & Scheduling) on the basis of specifications from different sources and that this planning is then implemented or executed (Execution). The collected data is analyzed (Analytics) in order to make predictions (Prediction) which, together with other findings, can then be integrated in planning. The Industrial Internet of Things supports this cycle by collecting and providing data and by local real-time applications in the shop floor. Many of these tasks can be performed efficiently with products available on the market, such as an MES - for others, new products will be gradually launched on the market.

PLANNING & SCHEDULING:

Plan and prepare

The element „Planning & Scheduling" contains functions and applications executing general tasks of the work preparation. This includes the planning and scheduling of orders and operations, as well as resources and employees. However, quality assurance and maintenance activities must also be planned and sometimes be scheduled. Last but not least, it is important to integrate both the material input and the energy requirements of pending production orders. Even if more and more processes in the Smart Factory become self-regulating in the future, it will still require a system that plans what is to be produced based on specifications from the ERP system and simultaneously resolves conflicting planning targets. That is where MPDV's Advanced Planning and Scheduling System (APS) FEDRA steps in. HYDRA X provides useful functions and applications for maintenance planning and inspection planning in quality assurance.

Sequence planning of orders and operations

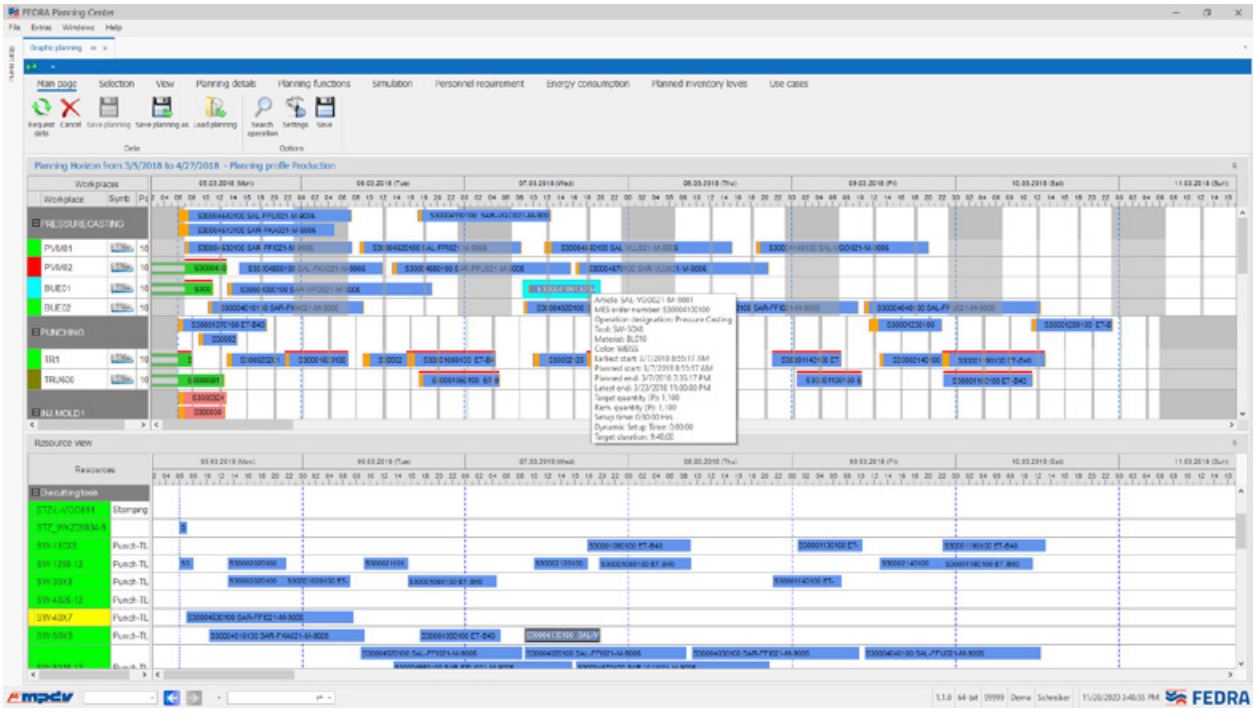
Resource assignment and maintenance calendar

Workforce planning

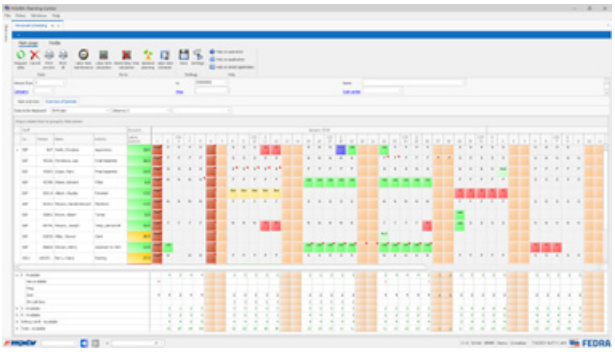
Work preparation and planning quality measures

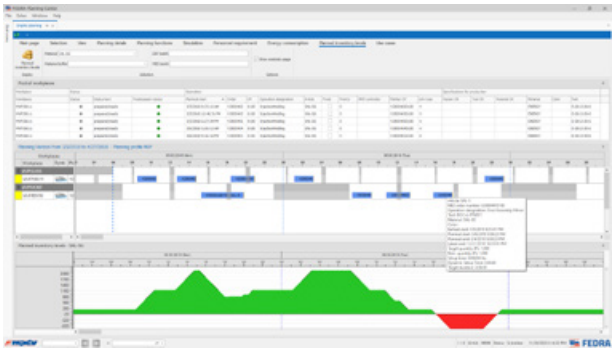
Planning of material and energy consumption

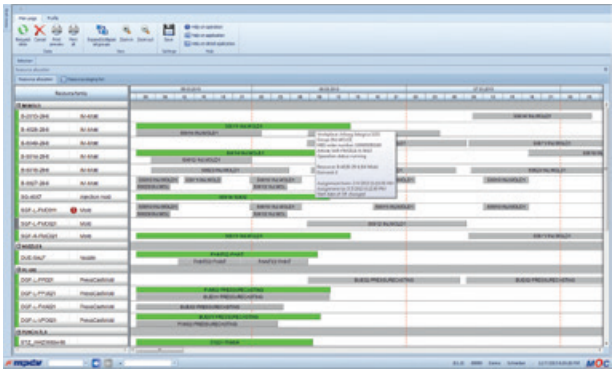
Example function in APS FEDRA:

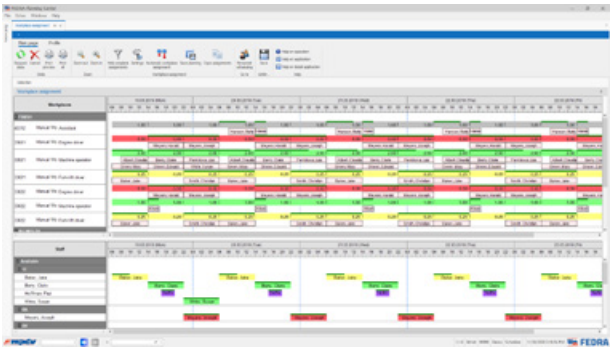


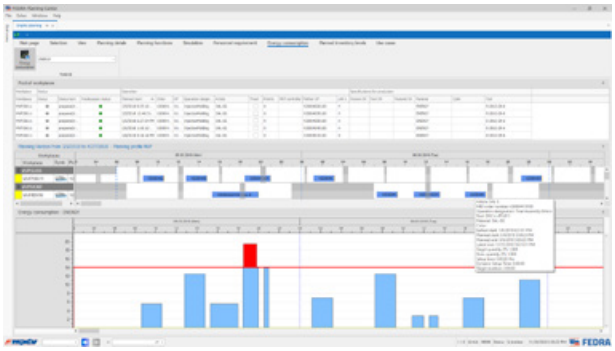
Example functions in APS FEDRA and MES HYDRA:

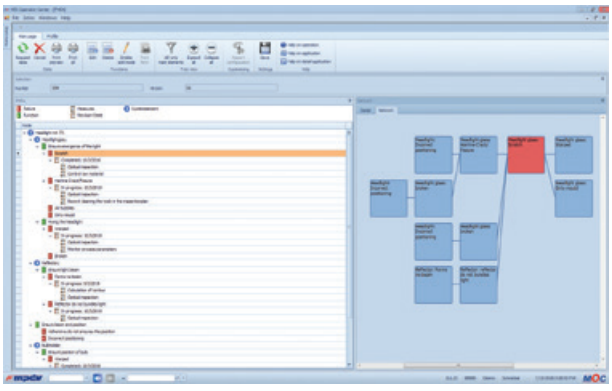


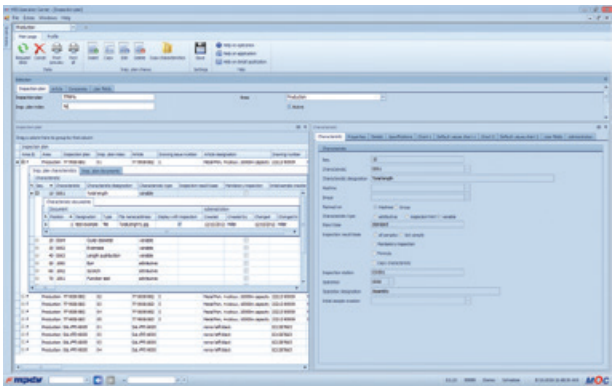












EXECUTION:

Execute, monitor and document

The element „Execution“ ensures that specifications are implemented and documented efficiently and correctly. This includes production control as well as continuous monitoring of process quality. There is also an option to implement a process interlocking system based on these applications. The online monitoring supports an early detection of deviations, which in turn increases the responsiveness of the shop floor workforce considerably. Throughout the production process, data is continuously collected and, depending on the regulations in force, stored for production documentation or traceability. MPDV's MES HYDRA X offers a wide range of valuable functions and applications tailored to these requirements.

Production control

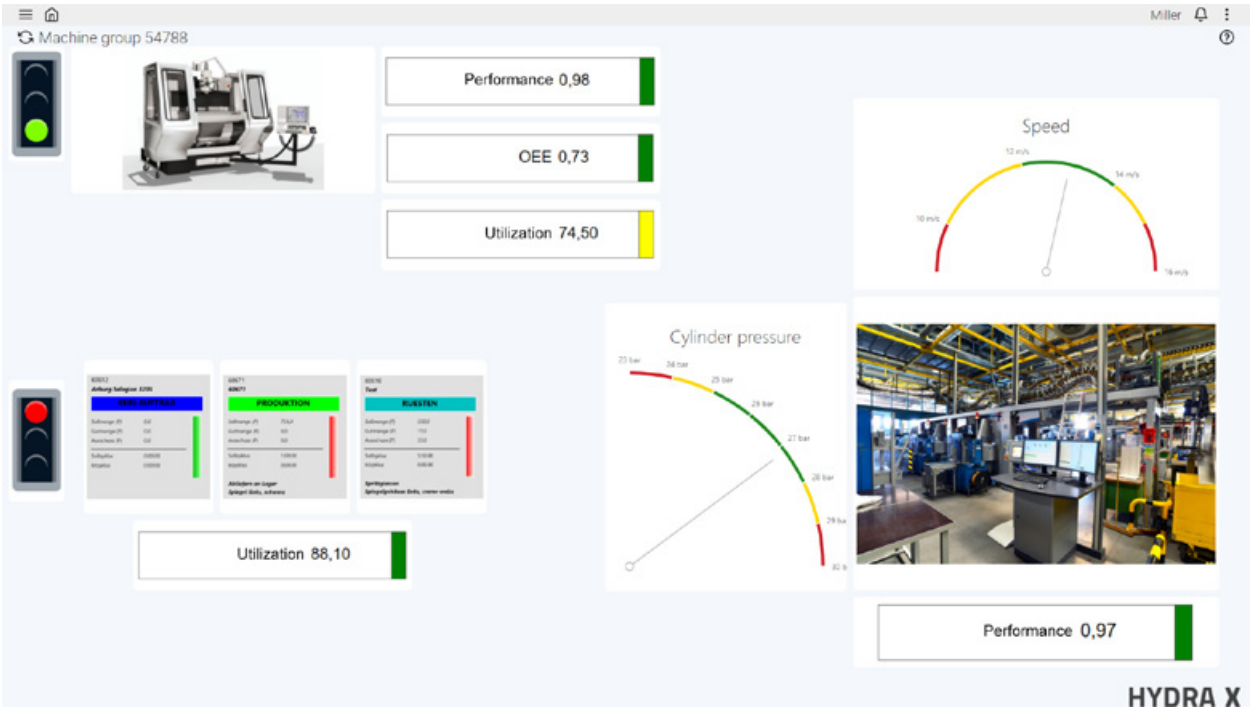
Monitoring process quality

Process interlocking

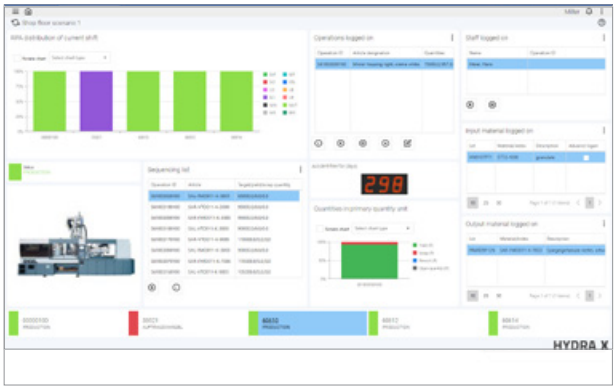
Online monitoring

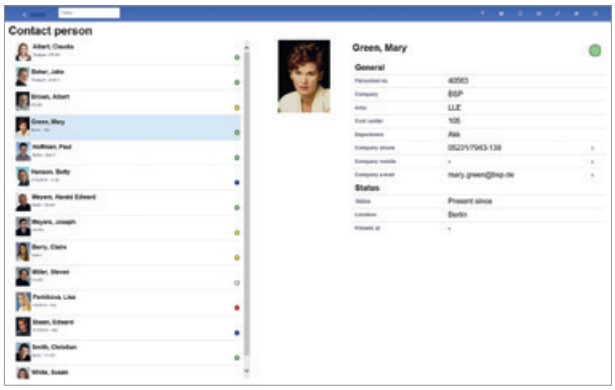
Real-time monitoring and early detection of deviations

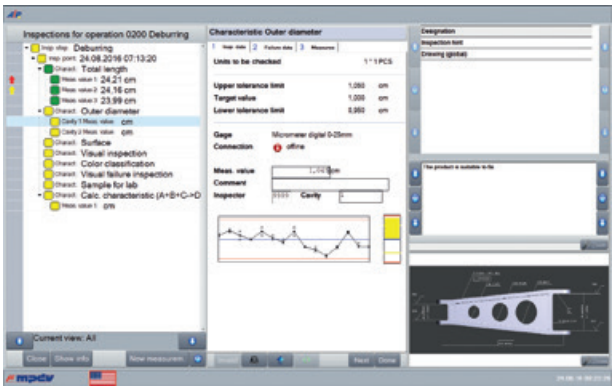
Example function in MES HYDRA:

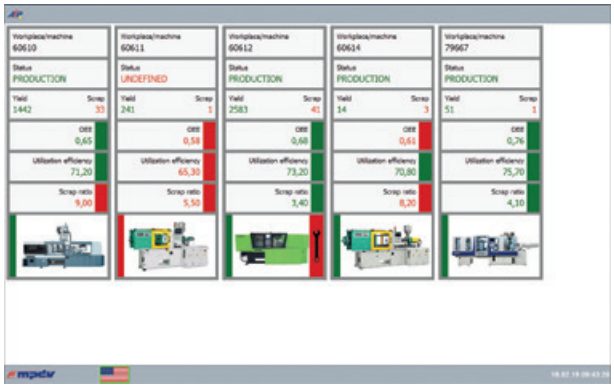


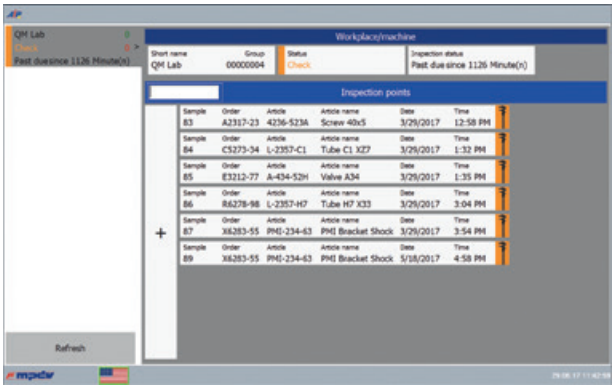
Example function in MES HYDRA:











ANALYTICS:

Evaluate and analyze

The functions and applications of the element „Analytics“ use artificial intelligence and other innovative methods to prepare the collected data for KPIs and reports. In addition to classic tables and diagrams, these applications also provide comprehensive long-term analyses and big data evaluations as well as flexible self-service analytics applications. The latter are particularly useful if a great deal of data from different sources is being correlated and evaluated by using different criteria. Classic self-service analytical tools include pivot tables, intelligent filters, and drill-down functions. MPDV's MES Cockpit is a product for self-service analytics which is already available. HYDRA X also offers a wide range of functions and applications to evaluate and analyze data from the shop floor. An example to illustrate the use of artificial intelligence (AI) is MPDV's shift-based Capacity Utilization Analysis.

KPIs

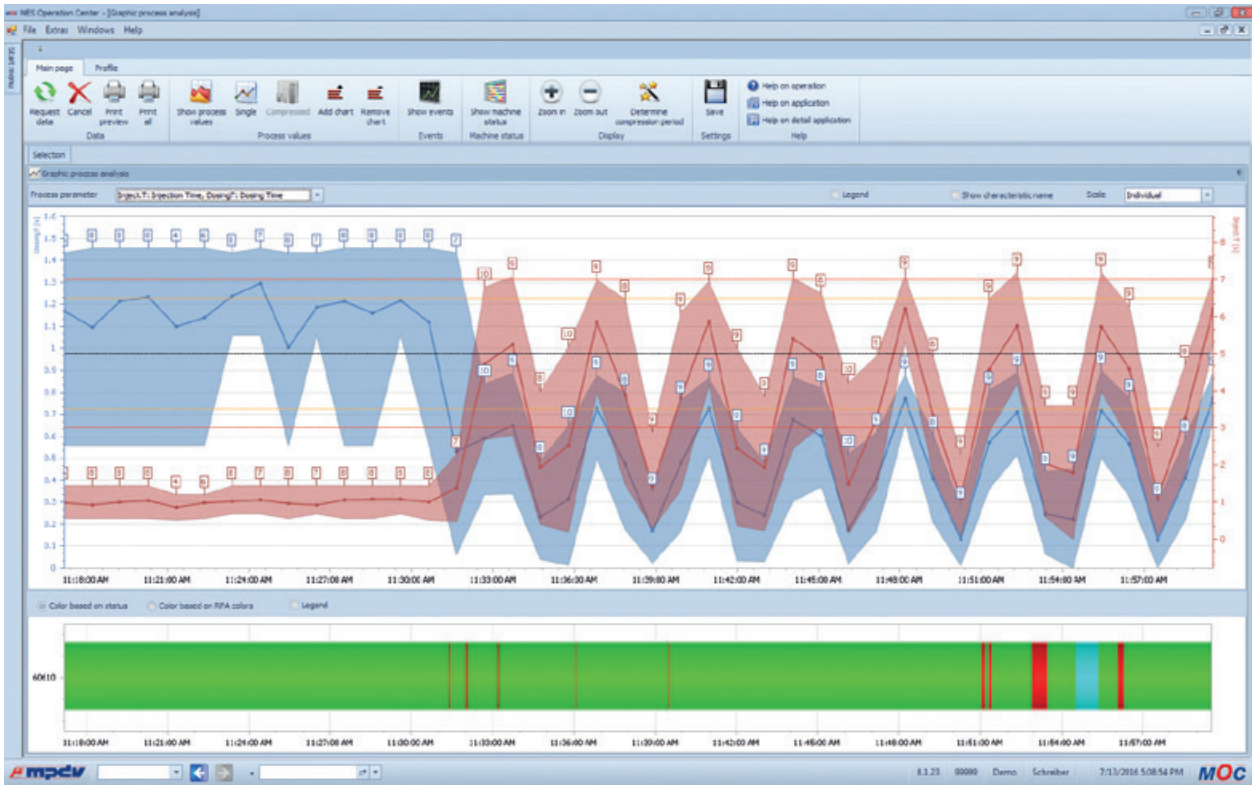
Performance and correlation analyses

Root cause analysis

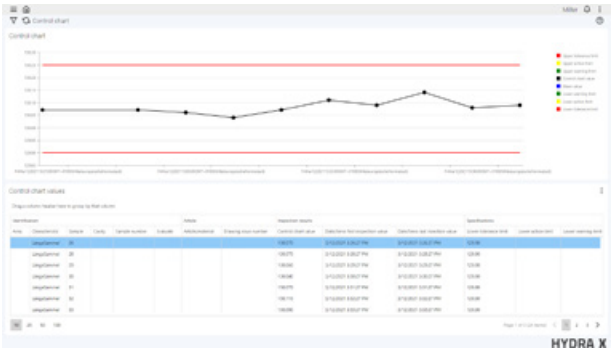
Self-service analytics

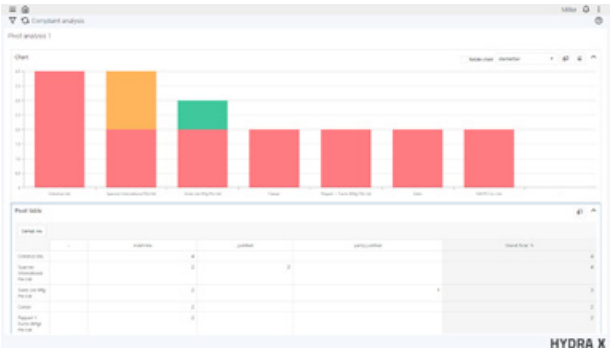
Machine learning based on big data

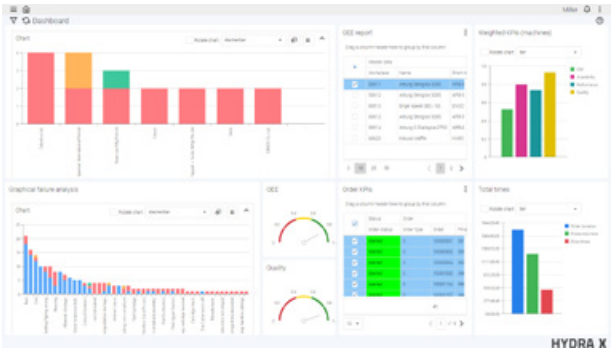
Example function in MES HYDRA:

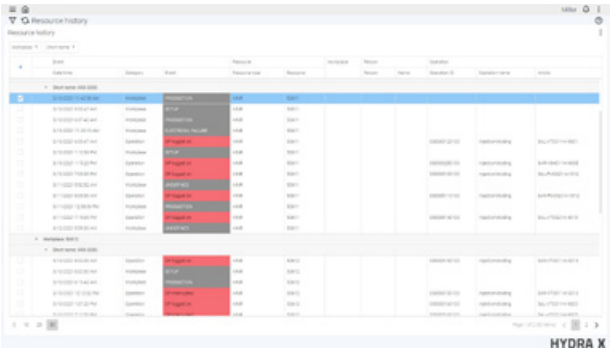


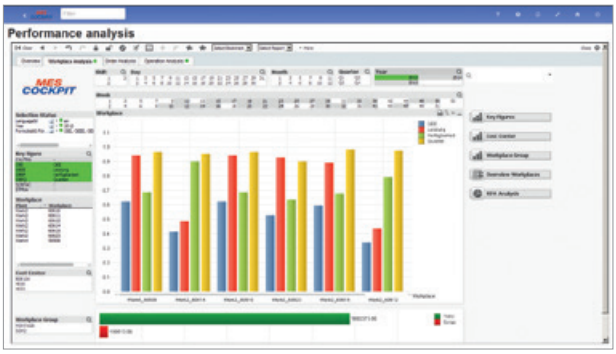
Example function in MES HYDRA and MES Cockpit:

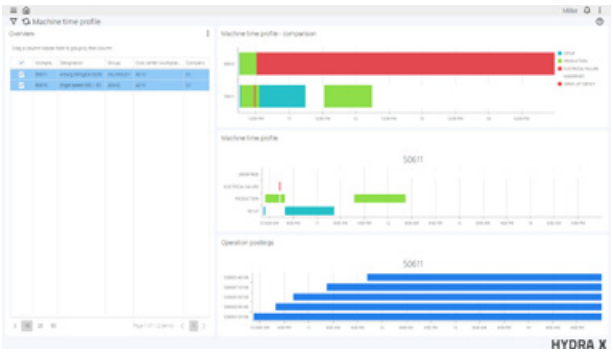


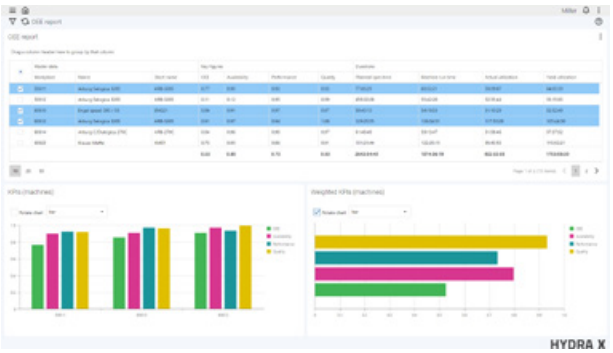












PREDICTION:

Predict and optimize

Based on statistical methods and artificial intelligence, functions and applications of the element „Prediction“ enable forecasts of all kinds. Typical applications are predictive maintenance or material range projection. Applications such as Predictive Quality provide a completely new aspect: they predict the quality of an article during production by using collected process data and stored models. Further applications of this nature are possible in many areas of production, which also promotes the economical use of all resources. For instance, HYDRA X features an application to predict setup time integrating any influencing factors.

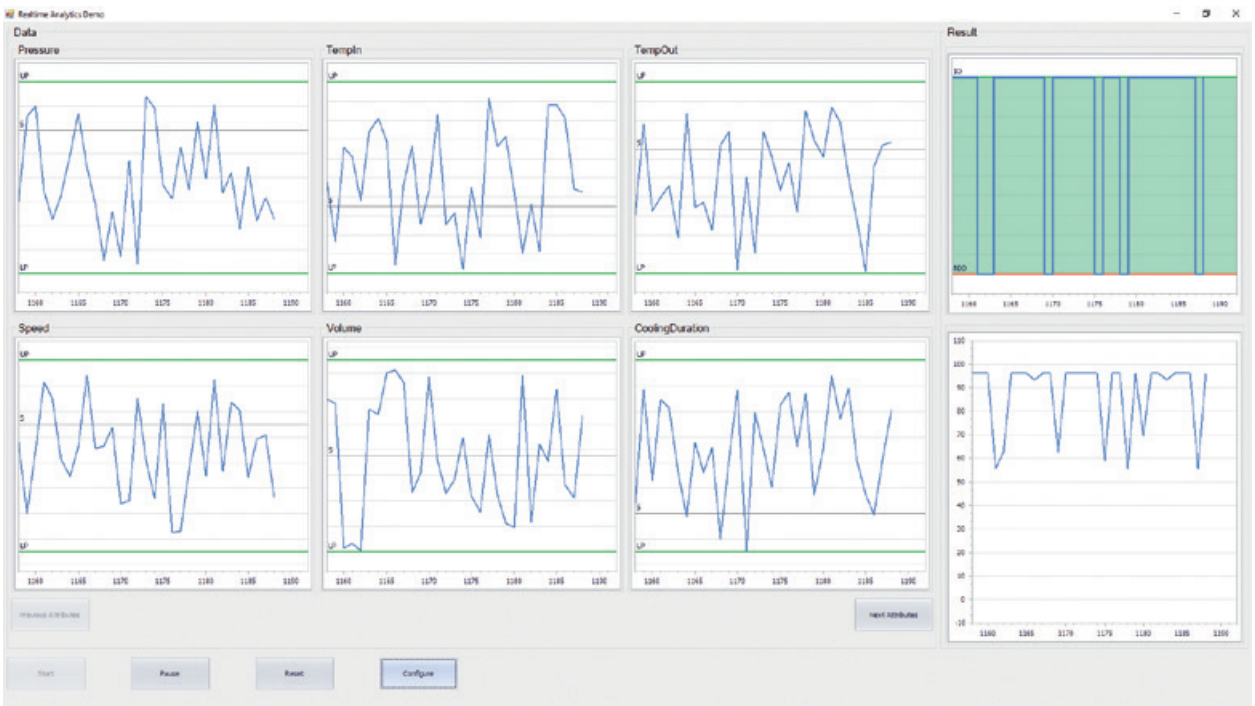
Predictive quality

Predicting production dates

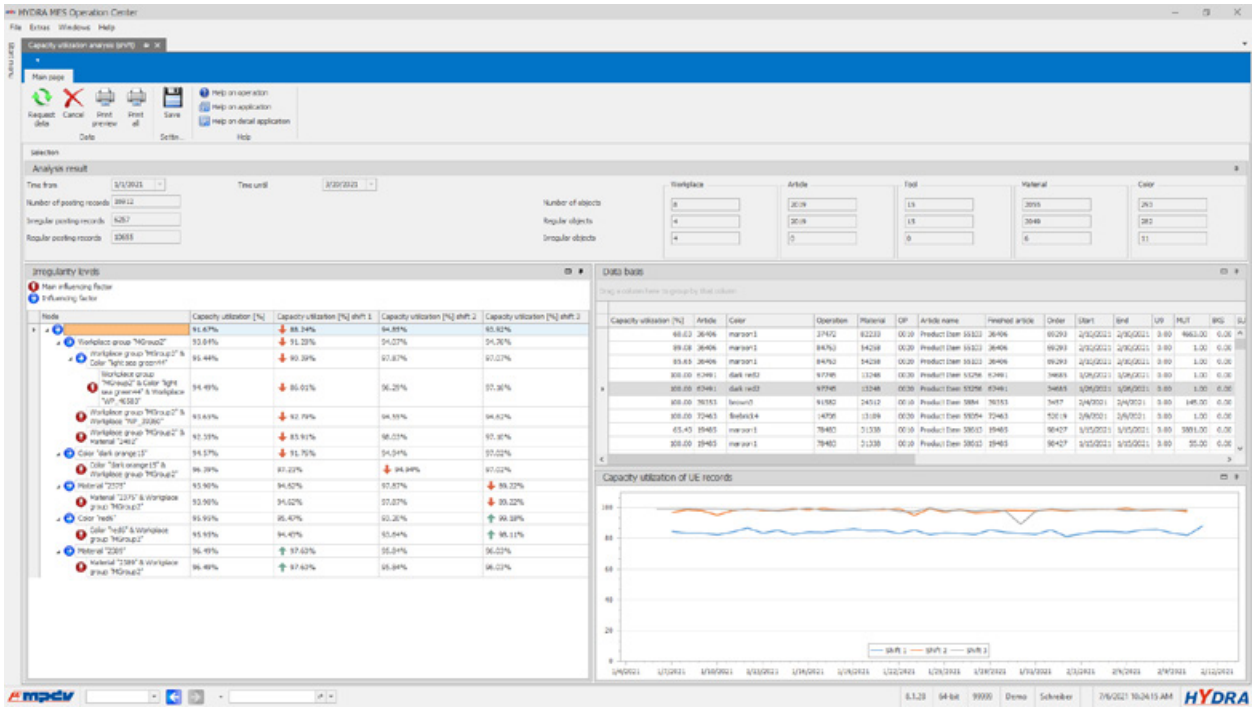
Predictive maintenance

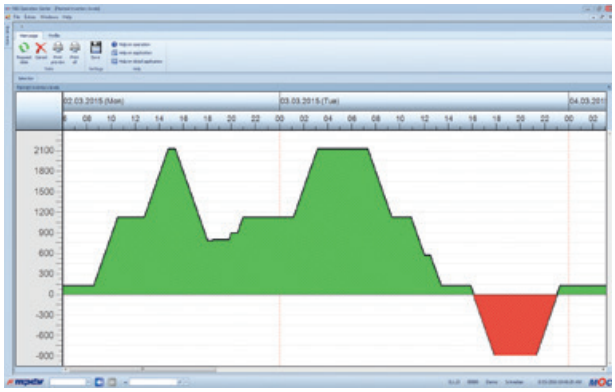
Calculating material range

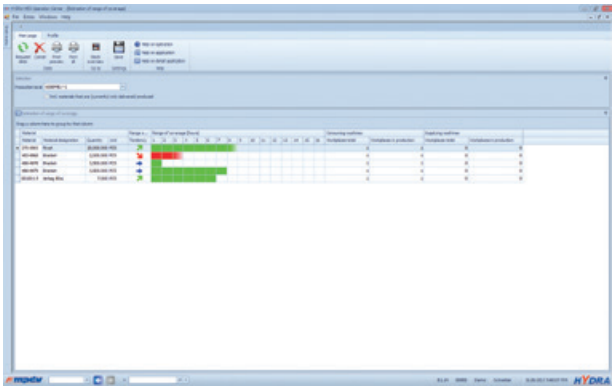
Example function in MES HYDRA:

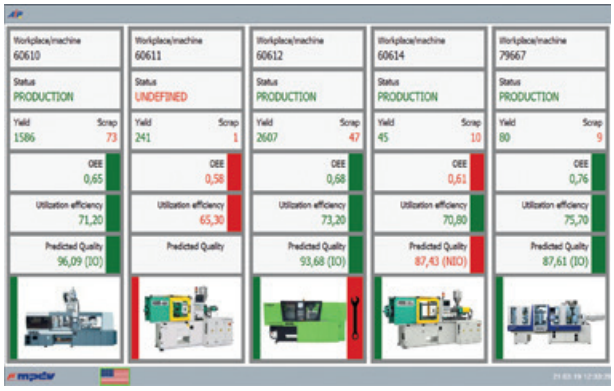


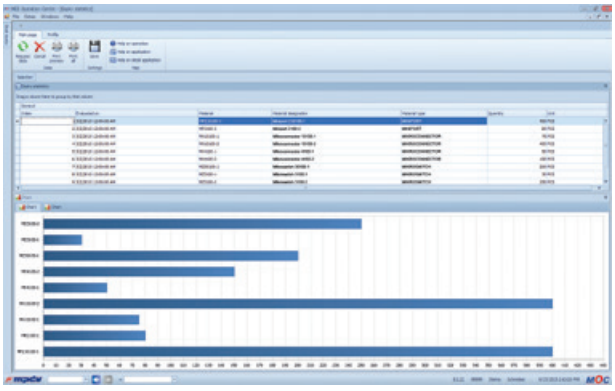
Example function in MES HYDRA:











INDUSTRIAL INTERNET OF THINGS:

Network and support

By means of networking and edge computing, functions and applications of the element „Industrial Internet of Things“ (IIoT) connect the operator and the real world with the digital image of the Smart Factory. Many well-established applications such as the automated transfer of data, digital machine connection and manual data collection are used for this purpose. The provision of information in the shop floor or process-oriented operator guidance are also of great importance, especially in factories whose workflows are governed by assembly processes. Apart from the technologies used, these applications ensure that all other Smart Factory Elements are supplied with current data or that their data is available on the shop floor at the right time. In particular, the mApps of the HYDRA X category Assembly Management control and monitor in real time critical processes that typically occur in highly diverse series production. In addition, the Shop Floor Messaging Services of HYDRA X support the operator by providing direct and system-supported communication. In line with the IIoT element, the Manufacturing Integration Platform (MIP) serves as a universal information and data hub, but can also connects applications from different suppliers.

Data transfer from IIoT sensors

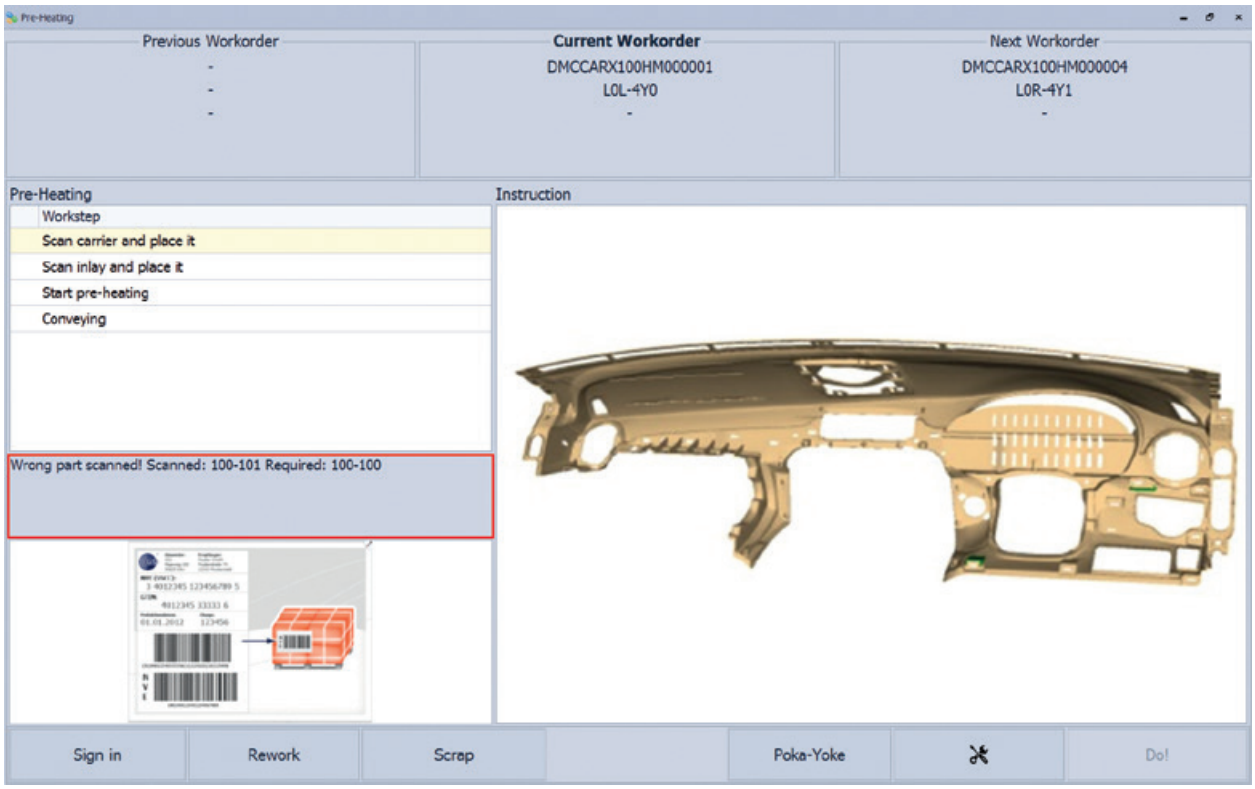
Digital machine connections

Manual data collection

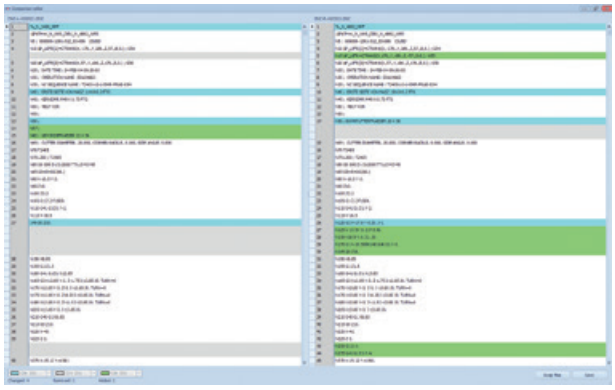
Providing information to the shop floor

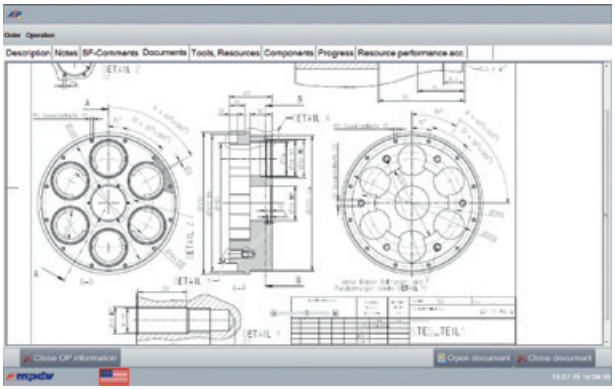
Flexible operator guidance

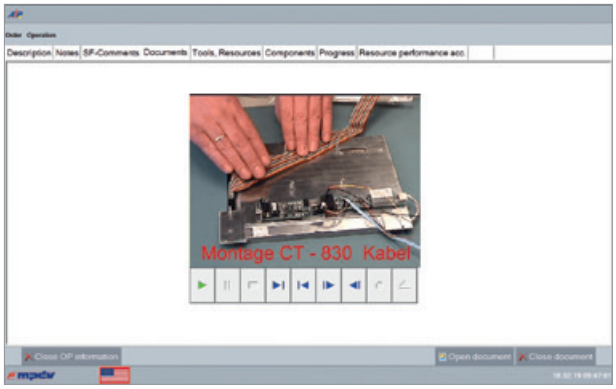
Example function in MES HYDRA:

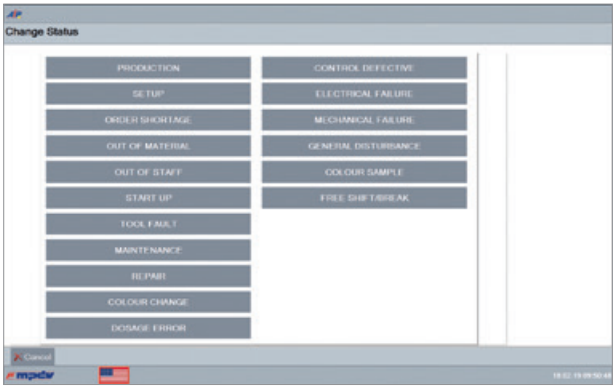


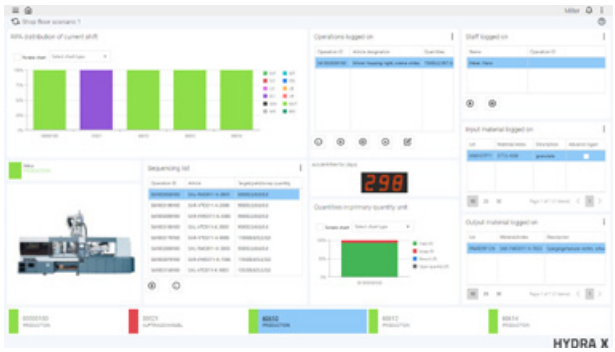
Example function in MES HYDRA:

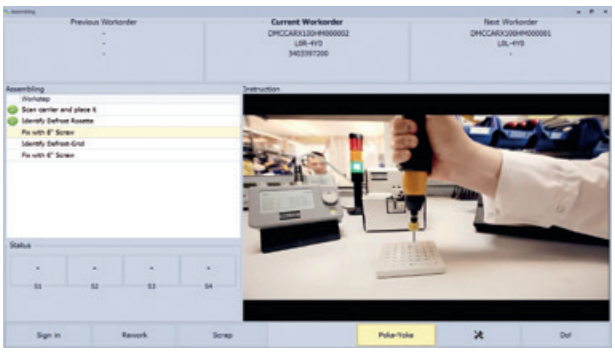


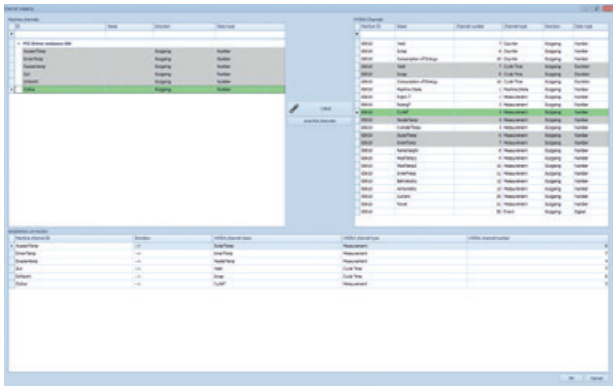


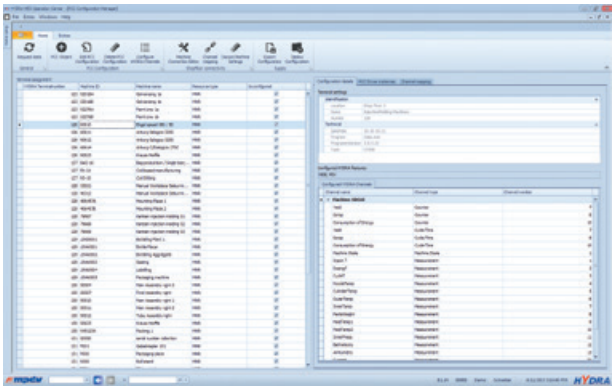






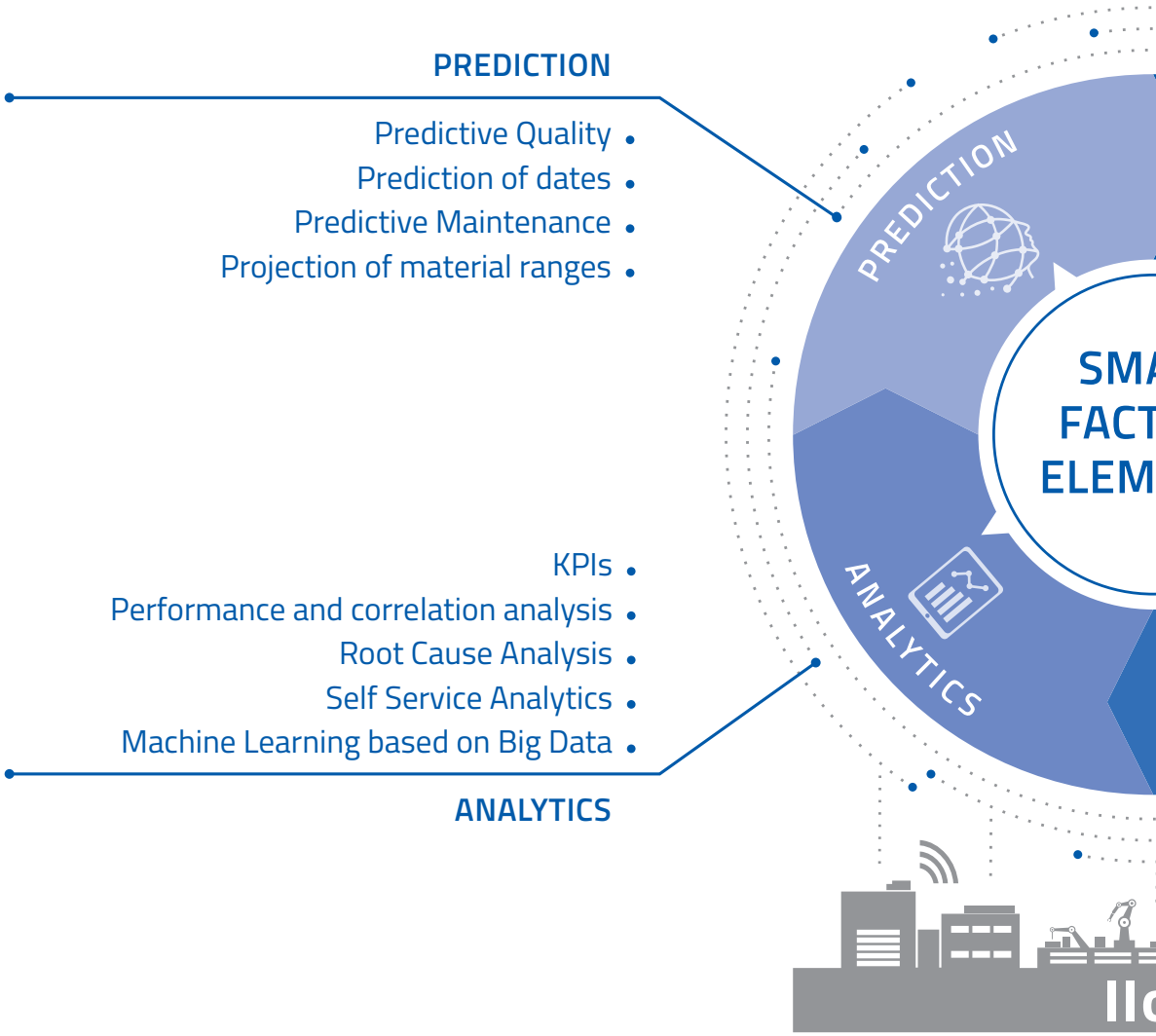






PREDICTION

- Predictive Quality
- Prediction of dates
- Predictive Maintenance
- Projection of material ranges

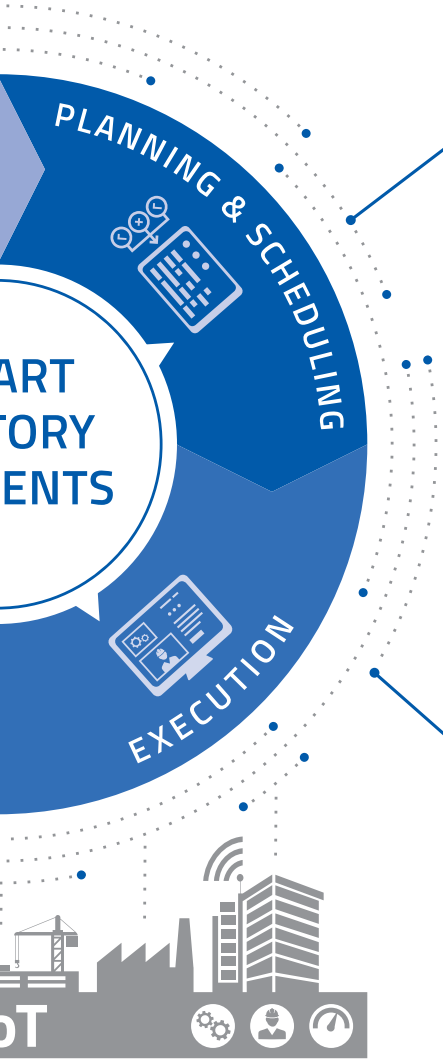


- KPIs
- Performance and correlation analysis
- Root Cause Analysis
- Self Service Analytics
- Machine Learning based on Big Data

ANALYTICS

INDUSTRIAL INTERNET OF THINGS

- Data transfer from IIoT sensors
- Digital machine connections
- Manual data collection
- Providing information to the shop floor
- Flexible operator guidance



PLANNING & SCHEDULING

- Sequence planning of orders and operations
- Resource allocation and maintenance calendar
- personnel scheduling
- Work preparation and quality planning
- Planning of material and energy use

- Production control
- Monitoring process quality
- Process interlocking
- Online monitoring
- Real-time monitoring and early detection of deviations

EXECUTION

Working world

Scenario based on the „Smart Factory Elements“ model

First, applications from the „Planning & Scheduling“ element accept several production orders from the higher-level ERP system and load them into appropriate planning tools (e.g. APS FEDRA) together with results from the „Analytics“ and „Prediction“ elements. For example, from „Analytics“ comes the information that article A can be produced 30% more efficiently on machine 1 than on machine 2 (by using the Capacity Utilization Analysis). „Prediction“ informs that machine 3 will fail with a probability of 75% in the next three days due to worn ball bearings (e.g. by using a predictive maintenance app connected via the MIP). Therefore, the responsible employee decides to schedule the accepted orders for article A on machine 1 and to distribute all the others to the remaining machines. At the same time, the employee schedules maintenance for machine 3 for the day after tomorrow in order to check the ball bearings and replace them if necessary. In quality management (e.g. HYDRA X Quality Management), it was stipulated some time ago that every 500th piece of all articles should be subjected to an inspection. This is a process where a variety of dimensions must be checked.

These plans then go to applications of the next element: „Execution“. Machine operators see the pending orders and log them on as soon as the previous order is completed (e.g. with HYDRA X Order Management). Simultaneously, an inspection order is logged on. Current KPIs and order progress are now continuously displayed on the operator terminal (e.g. with HYDRA X Resource Management). The operator is informed of a pending inspection after the first 500 pieces are produced (e.g. with the HYDRA X Quality Management).

The operator removes the relevant part and checks the specified attributes with a digitally connected caliper gauge. The system collects both the current production data (e.g. with the HYDRA X Resource Management) and the results of quality inspections (e.g. with HYDRA X Quality Management) by using interfaces from the element „IIoT“ (e.g. on the MIP). If the measured values deviate too much from the target values, production is stopped immediately and a fitter is notified to check the settings of the affected machine (e.g. with HYDRA X Information Management or third-party smartwatch solution connected via the MIP). The settings can then be adjusted if necessary. As soon as an inspection order is completed, the system logs the next one. On the next day, a maintenance employee checks the scheduled maintenance on machine 3, recording his working hours manually using an app on a smartphone (e.g. with an app from a third-party supplier connected to the MIP).

In the supervisor’s office, the shift manager uses the „Analytics“ functions to obtain an overview of the productivity and scrap rate of the current shift (e.g. with HYDRA X Information Management). In parallel, the supervisor analyzes the machine malfunctions of the last few days and correlates them with collected process and quality data (e.g. with the Capacity Utilization Analysis from HYDRA X). In doing so, the supervisor finds out that machine 5 is also suitable for producing article A with a high efficiency rate. The supervisor returns this information to the „Planning & Scheduling“ applications. If the analysis reveals correlations that require immediate intervention, they are immediately forwarded to the corresponding „Execution“applications.

Different „Prediction“ applications also work with the data collected by using the „Execution“ functions and continuously calculate the probability of machine malfunctions (e.g. with a predictive maintenance application of a third-party supplier connected via the MIP). The system also transmits these findings to the „Planning & Scheduling“ applications in order to plan for maintaining the machines and tools in question in good time. The company also uses the new application „Predictive Quality“. The process values (e.g. with HYDRA X Resource Management) collected during the production of article A form the basis for the prediction of the quality of each individual part. If a part is predicted with a high probability of a pass, it will end up in the box for the next work step. Parts that are predicted as rejects are immediately sent to the recycling box. All other parts are subjected to an additional visual inspection (e.g. with HYDRA X Quality Management) and then classified as good parts or rejects. The results from the „Prediction“ applications are transferred directly to the corresponding „Execution“ application (e.g. with HYDRA X Order Management).

To make it all work, different „IIoT“ applications connect the machines, provide input screens for the operator (e.g. with HYDRA X) and transmit all required documents and setting data (e.g. with HYDRA X Resource Management) to the shop floor.

Outlook

Even though many of the examples mentioned seem trivial at first, integration of in the „Smart Factory Elements“ model leads to increase in networking of applications. Interlocking processes become visible and the new perception ensures a greater transparency and efficiency in the shop floor. The functional range of a current MES system such as HYDRA X in combination with APS FEDRA already covers a large part of the applications mentioned here. However, new methods and tools (e.g. Predictive Quality) are also envisaged, especially for “Analytics“ and „Prediction“, to generate further insights and predictions from existing data. Thus, the „Smart Factory Elements“ model covers a wider range of applications than a classic MES. It is also evident that Smart Factory Elements are a good example that real added value can only be created by applications and that bare technology is often pushed into the background. Even in times of Industry 4.0, the focus continues to be on the actual task of production IT - and that is a good sign.

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About

MPDV Mikrolab GmbH

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MPDV Products such as the Manufacturing Execution System (MES) HYDRA, the Advanced Planning and Scheduling System (APS) FEDRA or the Manufacturing Integration Platform (MIP) enable manufacturing companies to streamline their production processes and stay one step ahead of the competition. The systems can be used to collect and evaluate production-related data along the entire value chain in real time. If the production process is delayed, employees detect it immediately and can initiate targeted measures.

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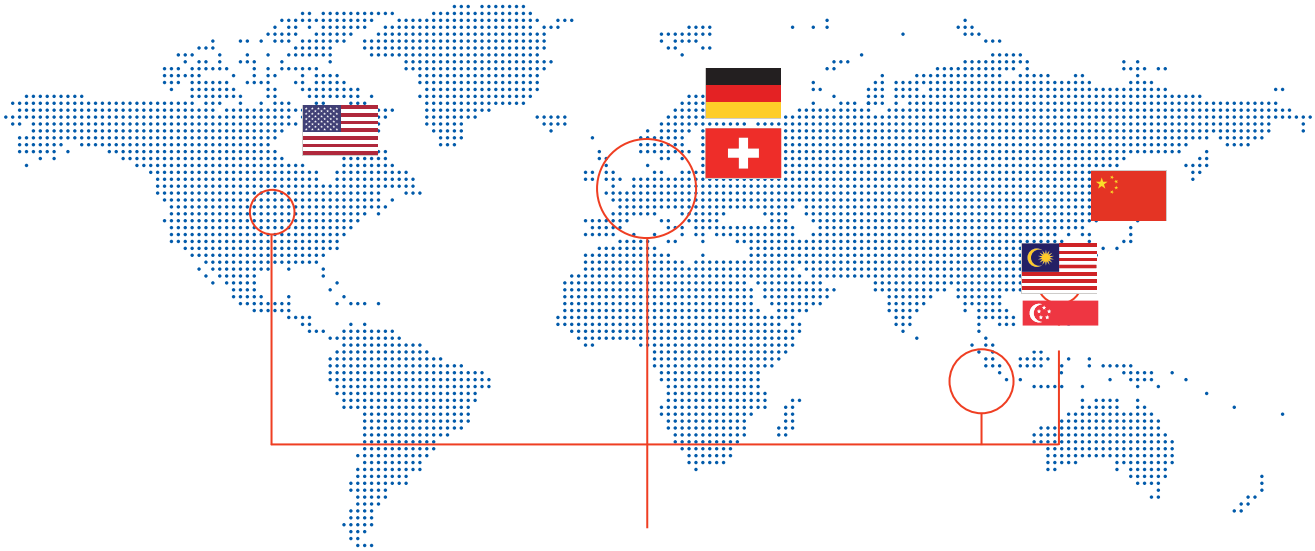

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