White paper

WE CREATE SMART FACTORIES

A model for the innovative production IT

Smart Factory Elements

MPDV Asia Pte Ltd
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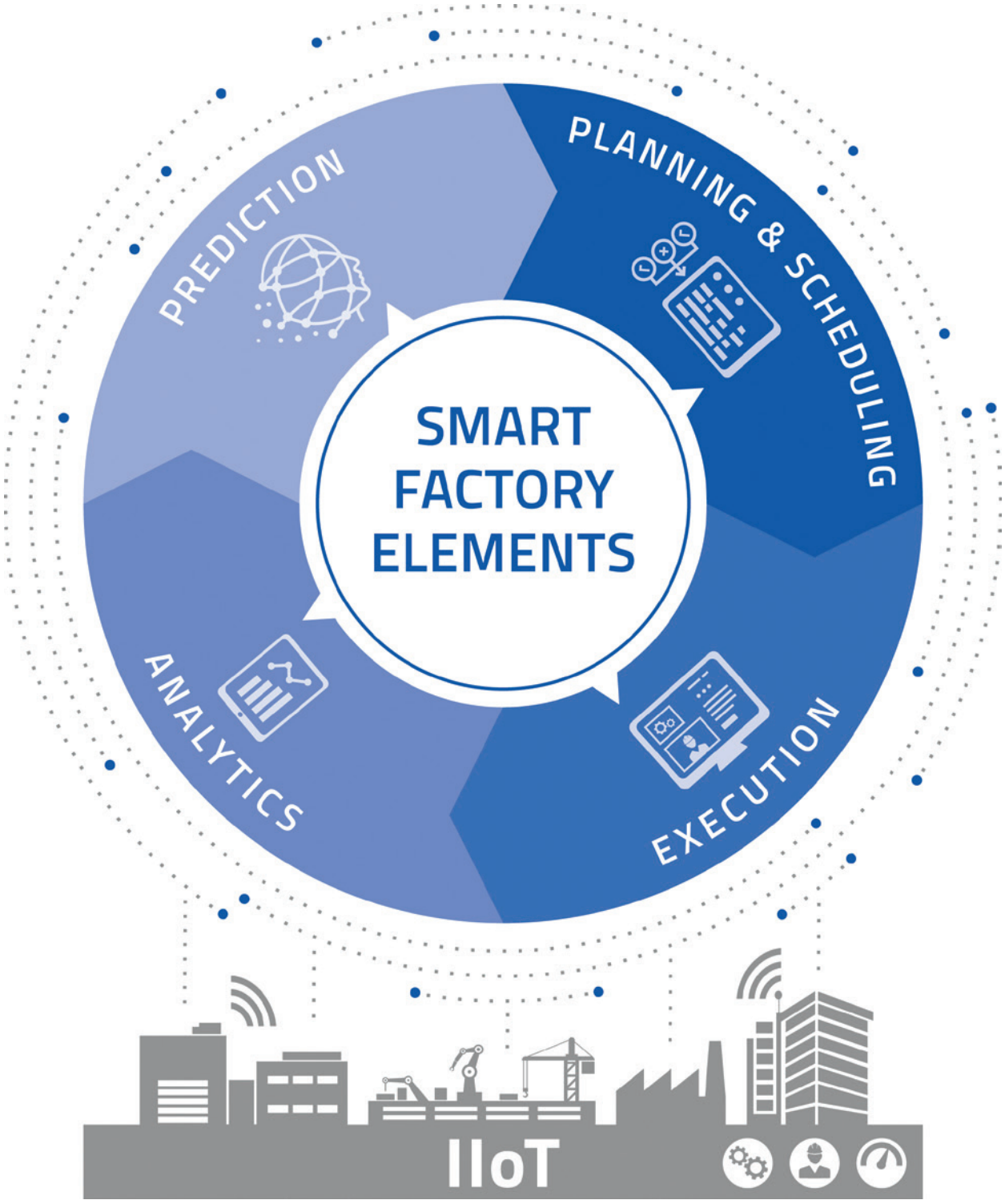
ASIA


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

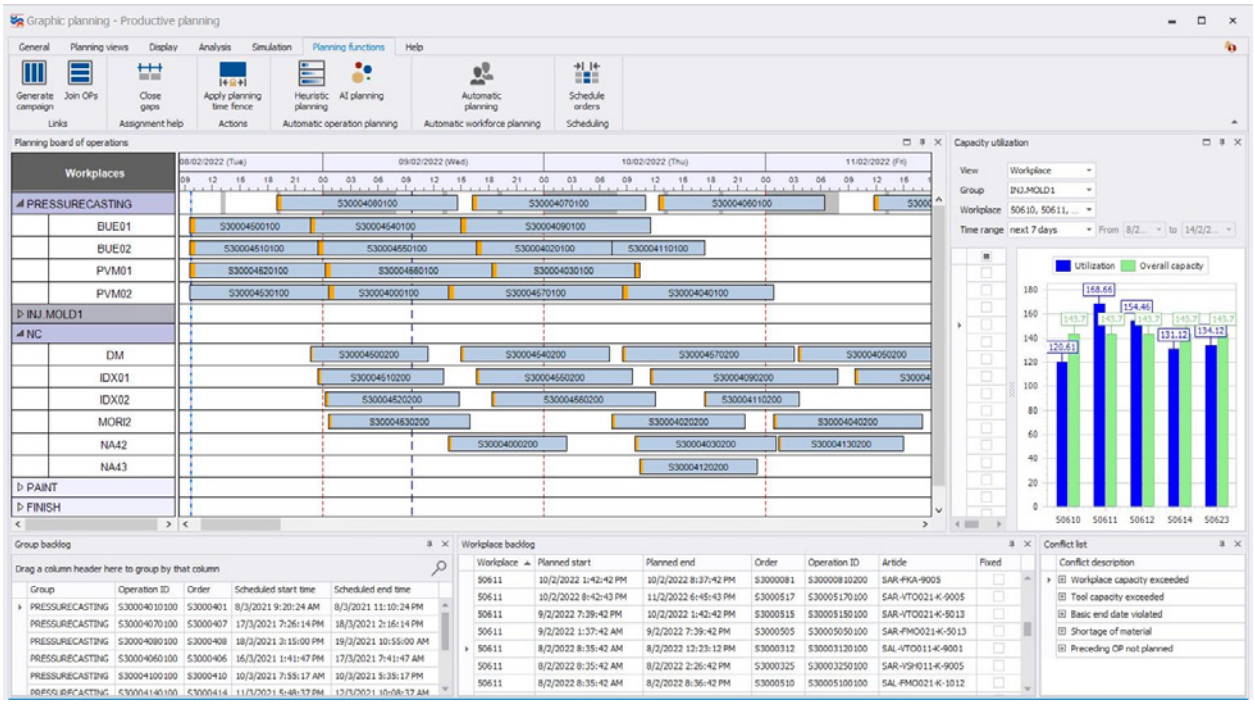
Workforce planning

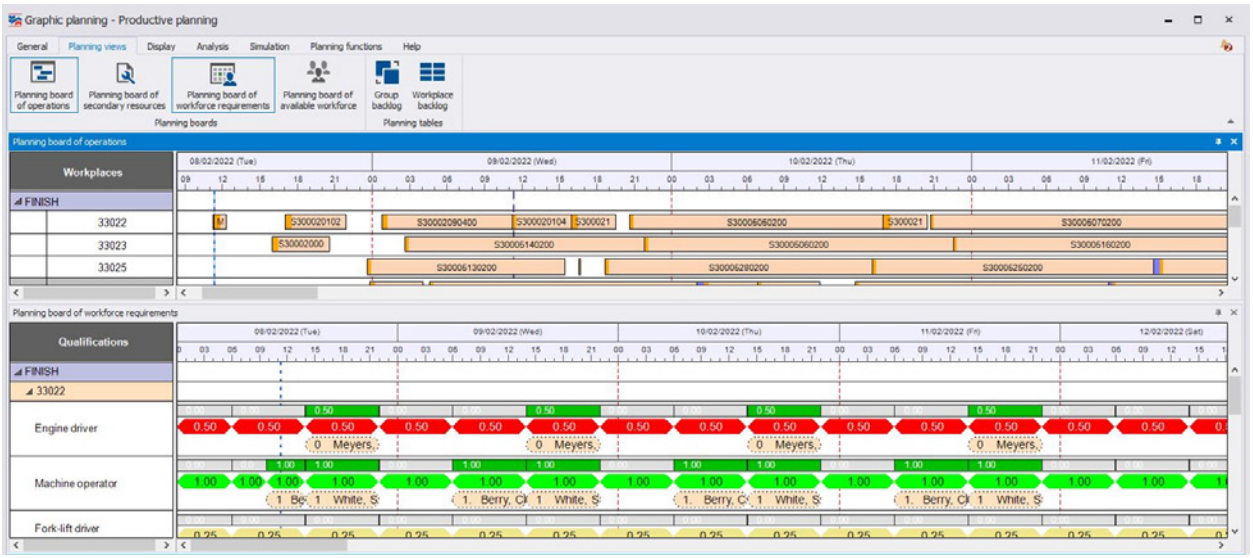
Work preparation and planning quality measures

Planning of material and energy consumption

Example function in APS FEDRA:

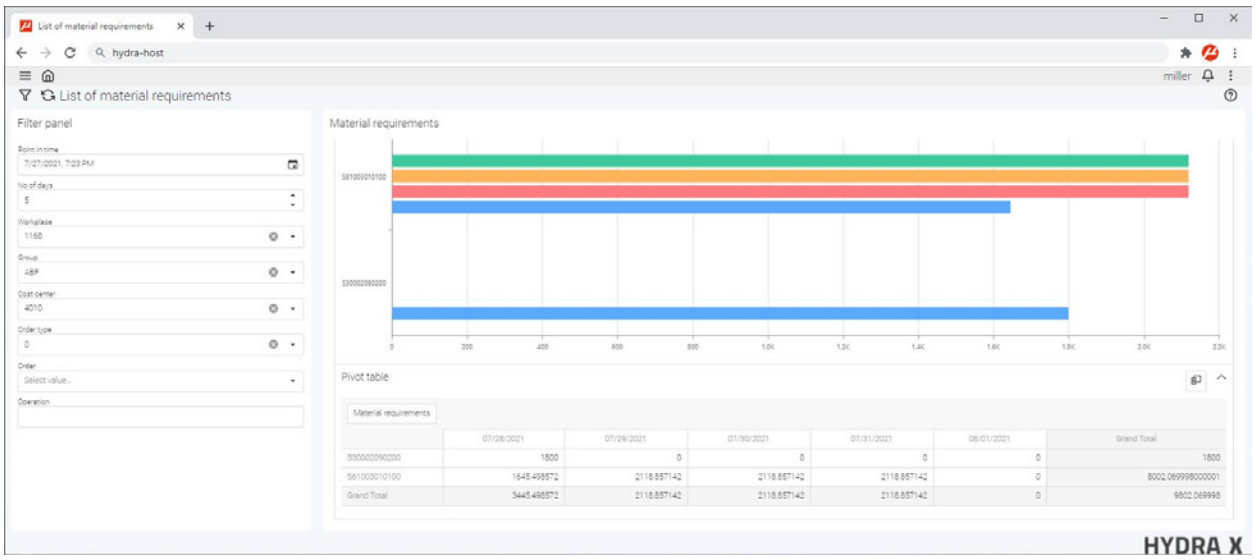
FEDRA





Example functions in MES HYDRA:

HYDRA X



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. Based on „Execution“ applications, there is also an option to implement a process interlocking system. 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 recorded and, depending on the regulations in force, stored for production documentation or traceability purposes.

Production control

Monitoring process quality

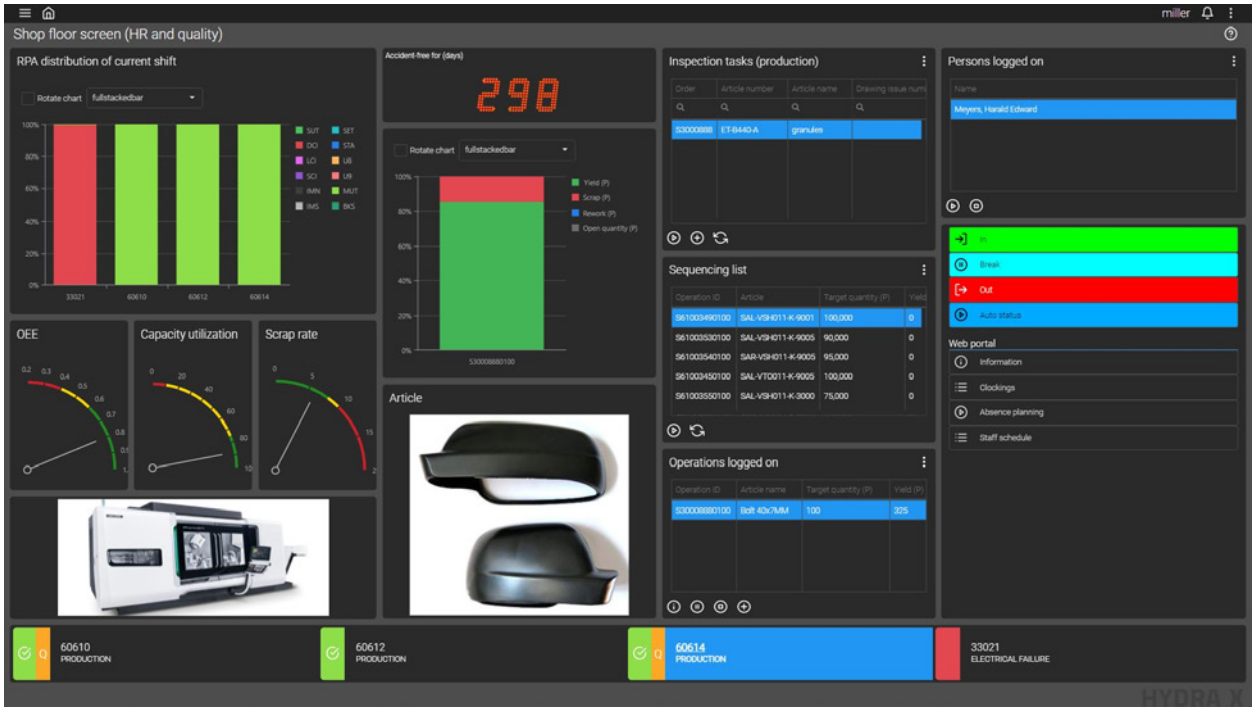
Process interlocking

Online monitoring

Real-time monitoring and early detection of deviations

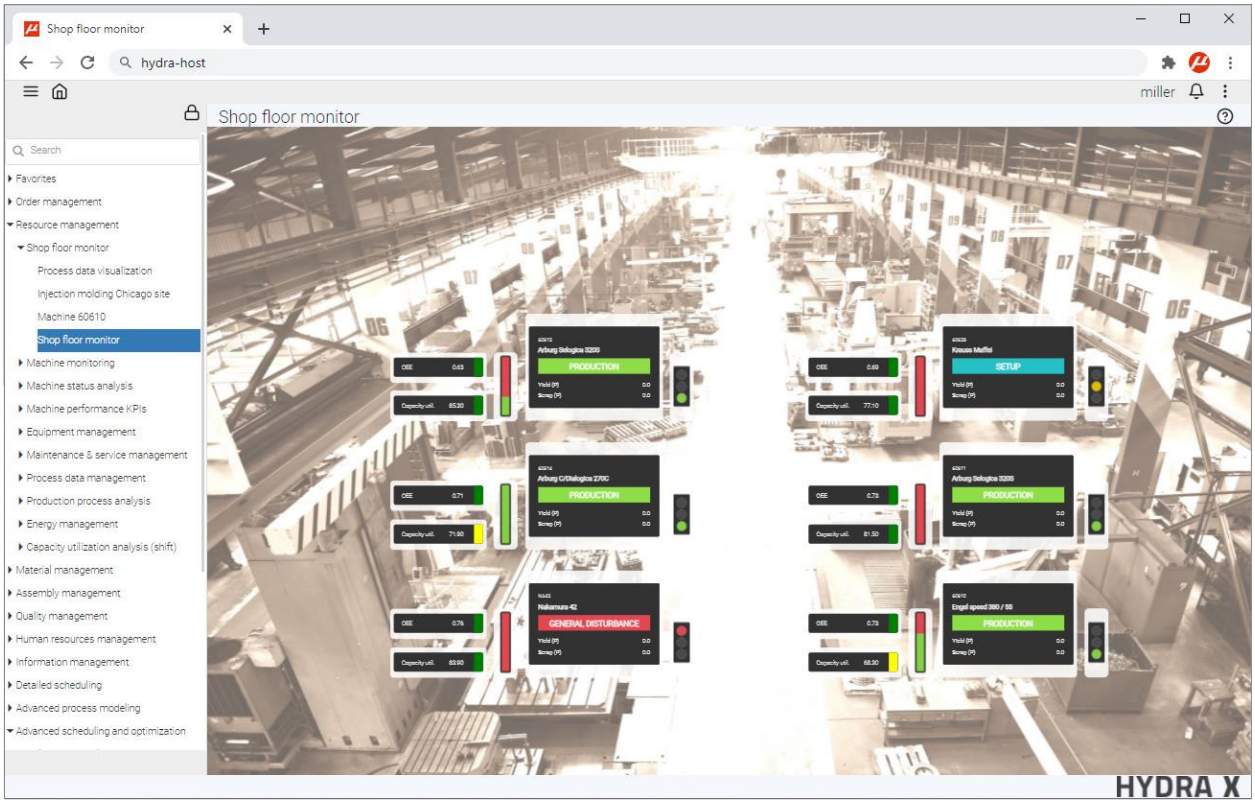
Example function in MES HYDRA:

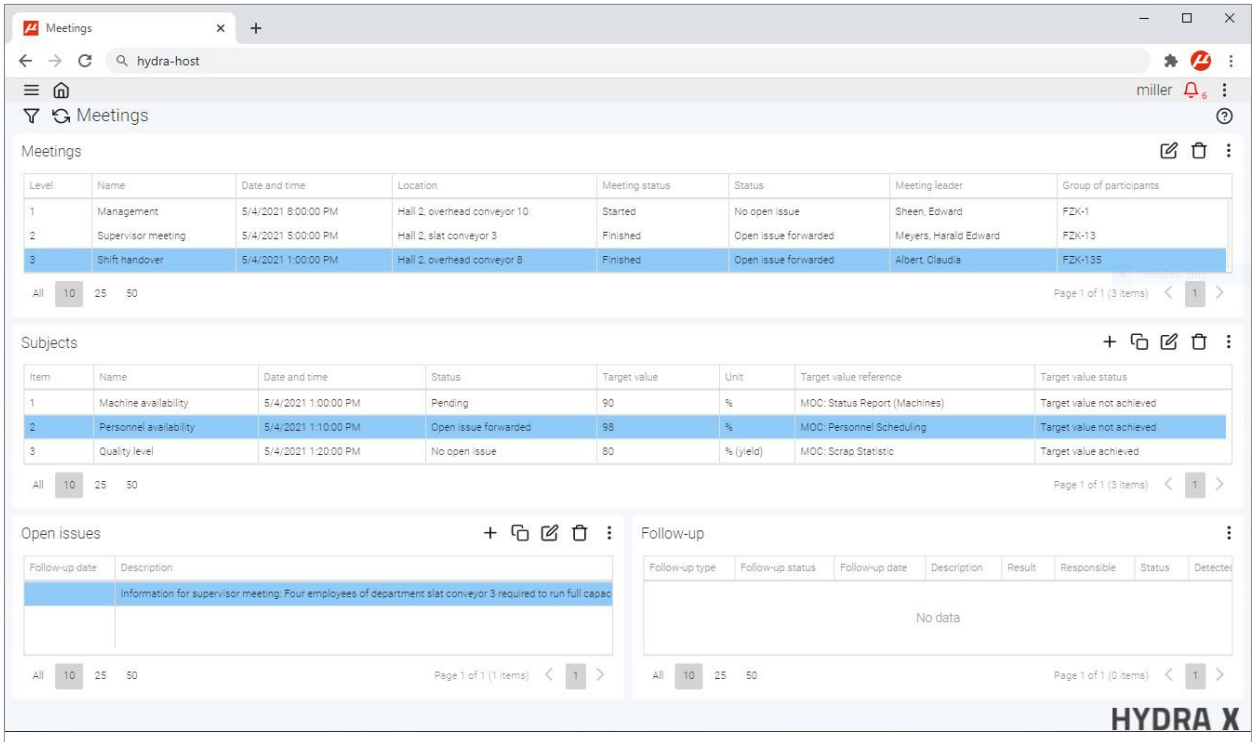
HYDRA X



Example function in MES HYDRA:

HYDRA X





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. HYDRA X 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

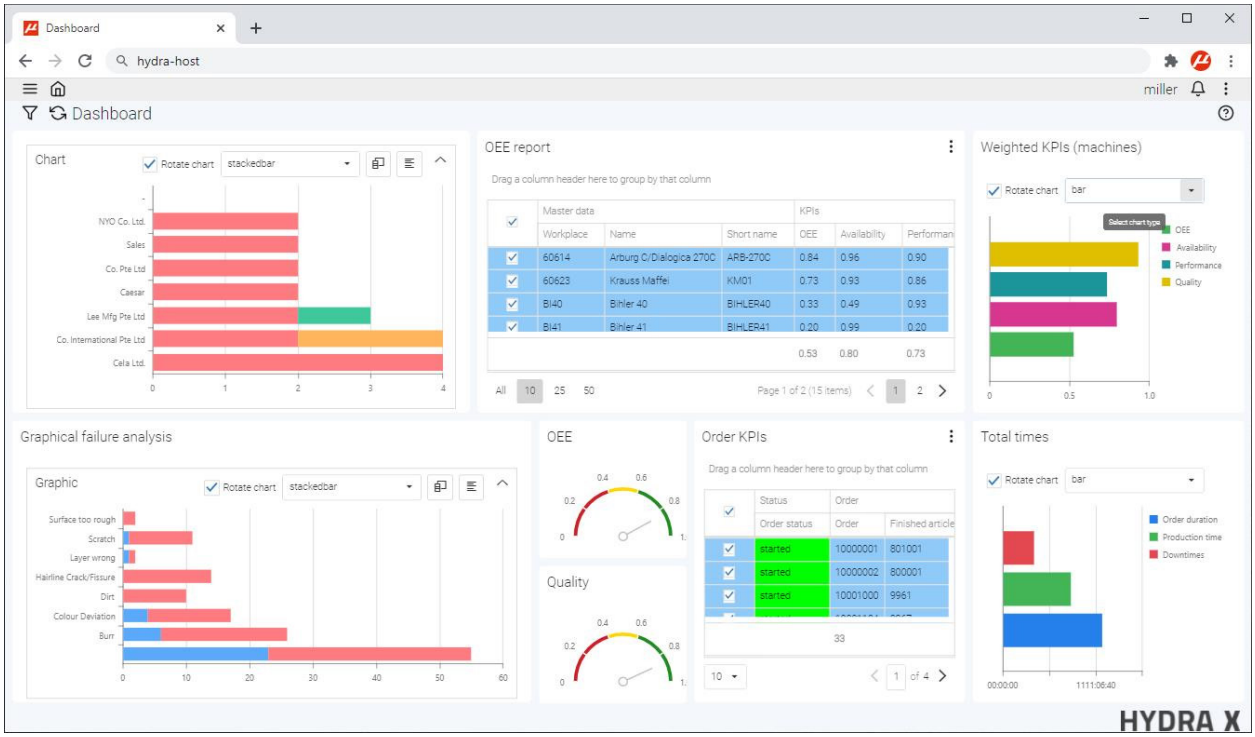
Performance and correlation analyses

Root cause analysis

Self-service analytics

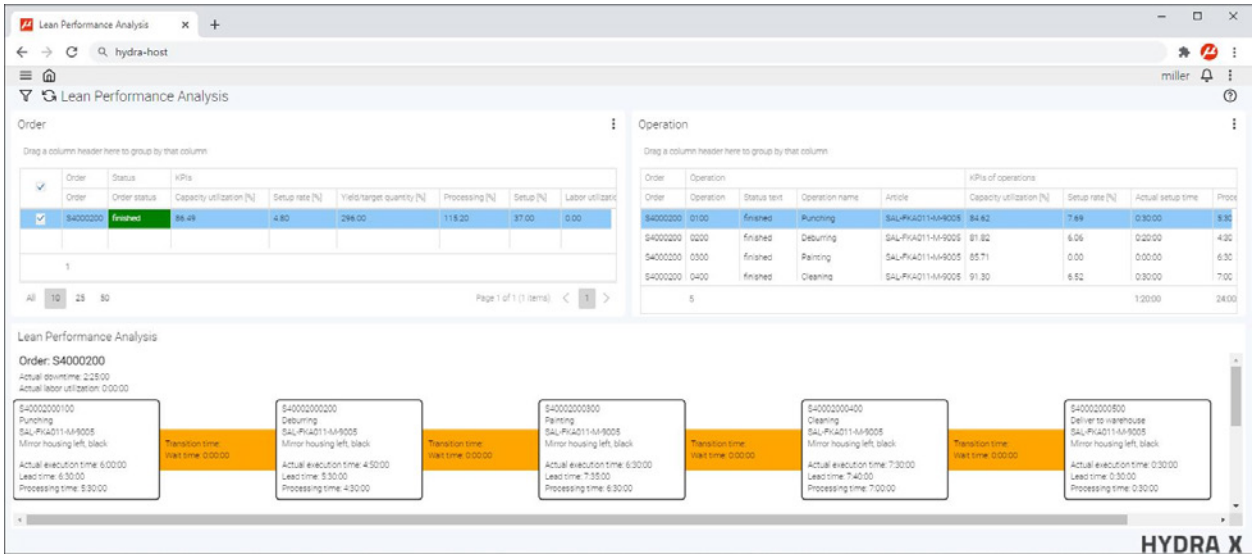
Machine learning based on big data

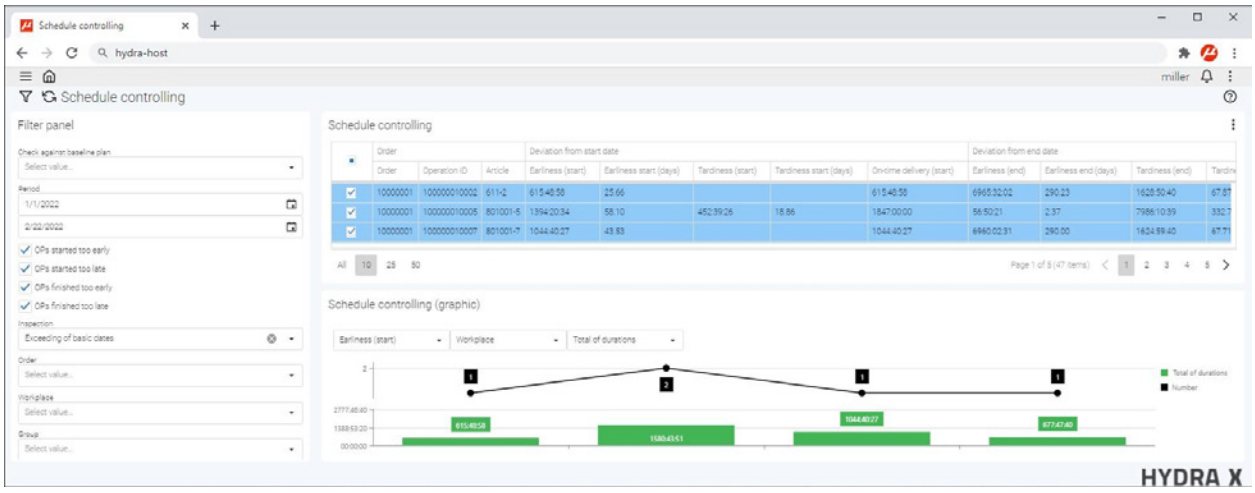
Example function in MES HYDRA:

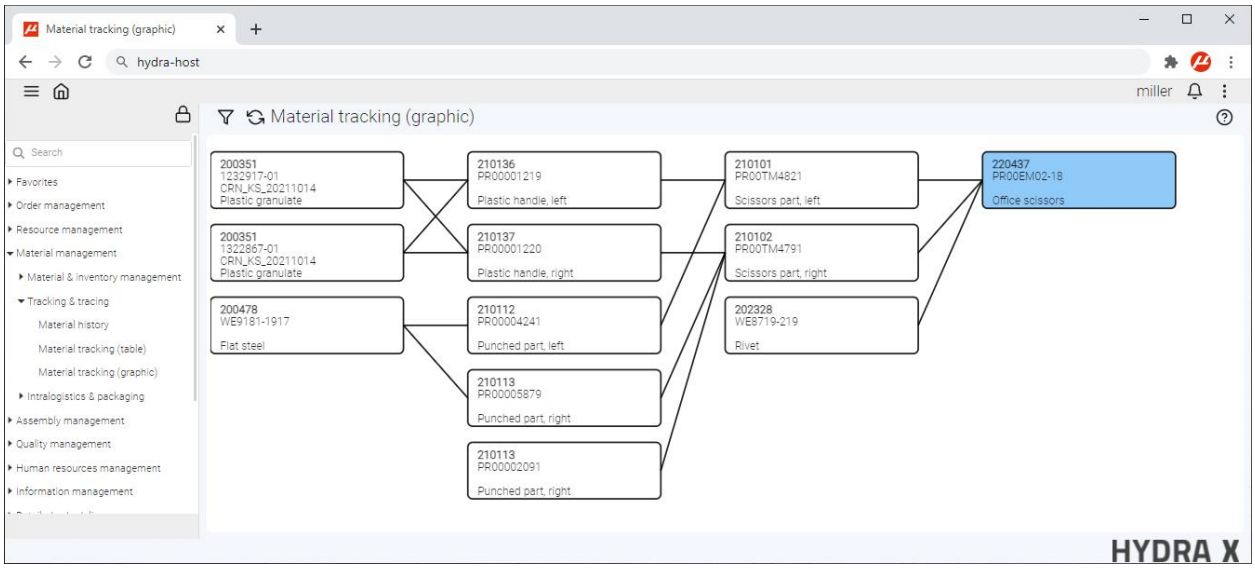


Example function in MES HYDRA and MES Cockpit:

HYDRA X







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

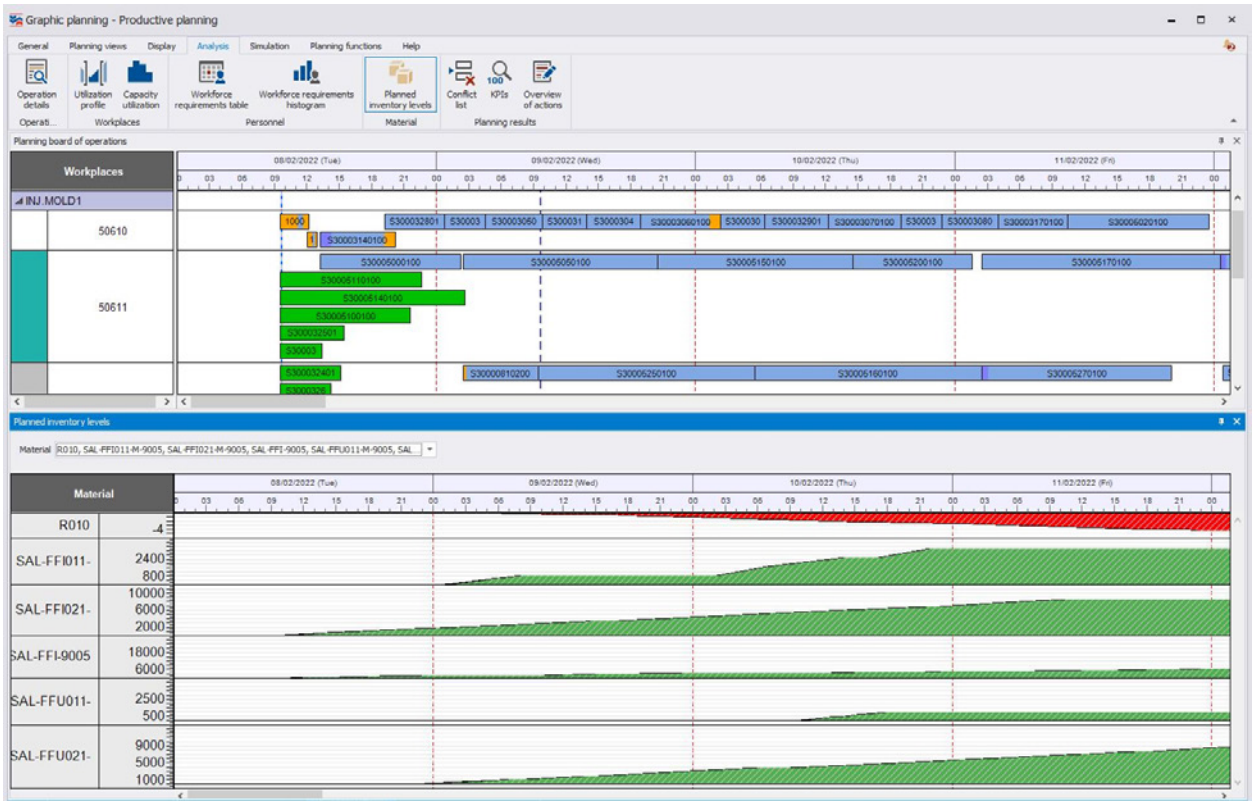
Prediction of dates

Predictive Maintenance

Projection of material range

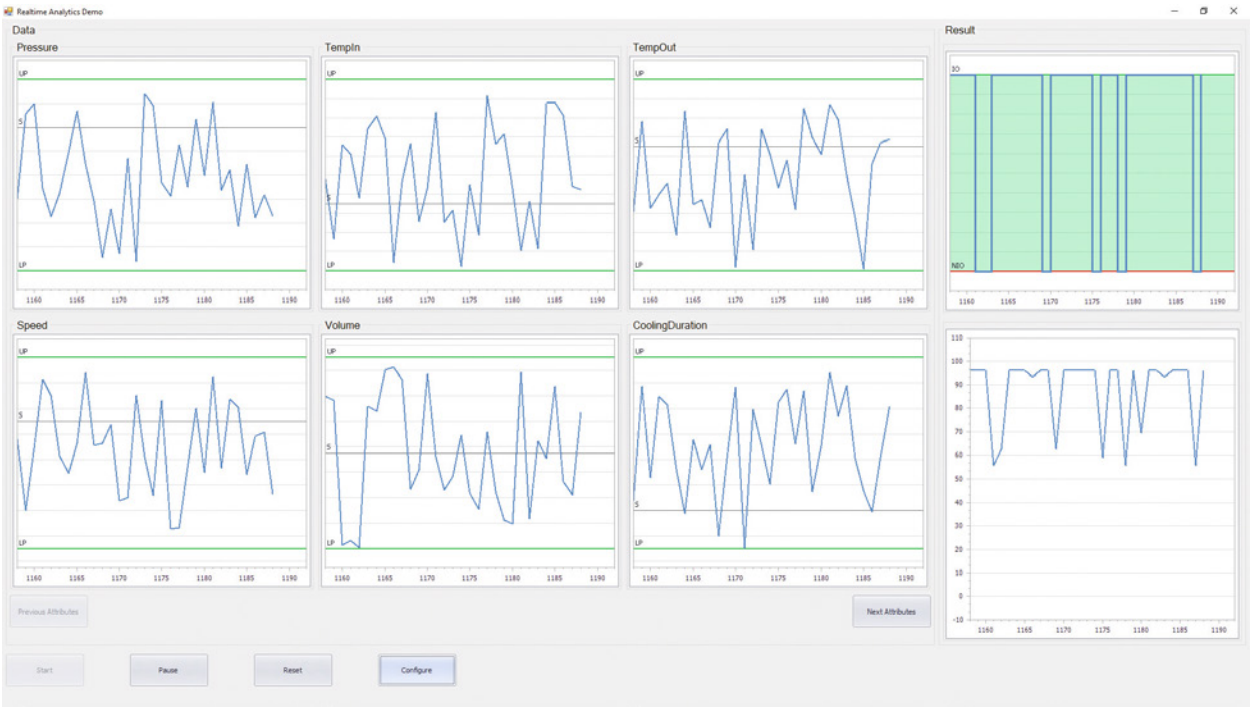
Example function in APS FEDRA:

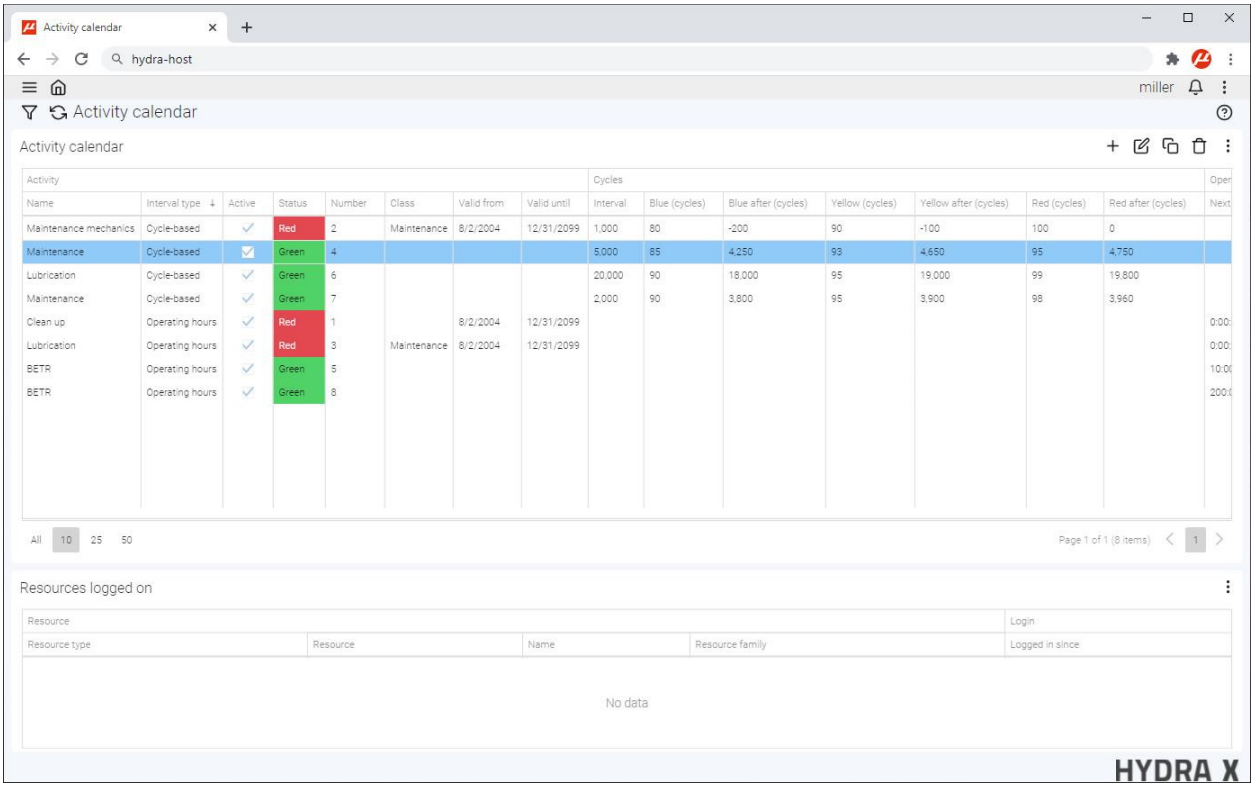
FEDRA



Example function in MES HYDRA:

HYDRA X





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. Especially in factories where assembly processes dominate, the supply of information in the shop floor or a customized operator guidance are of great importance. Apart from the technologies used, these applications guarantee that all other Smart Factory Elements are supplied with current data or that their data is available on the shop floor.

Data transfer from IIoT sensors

Digital machine connections

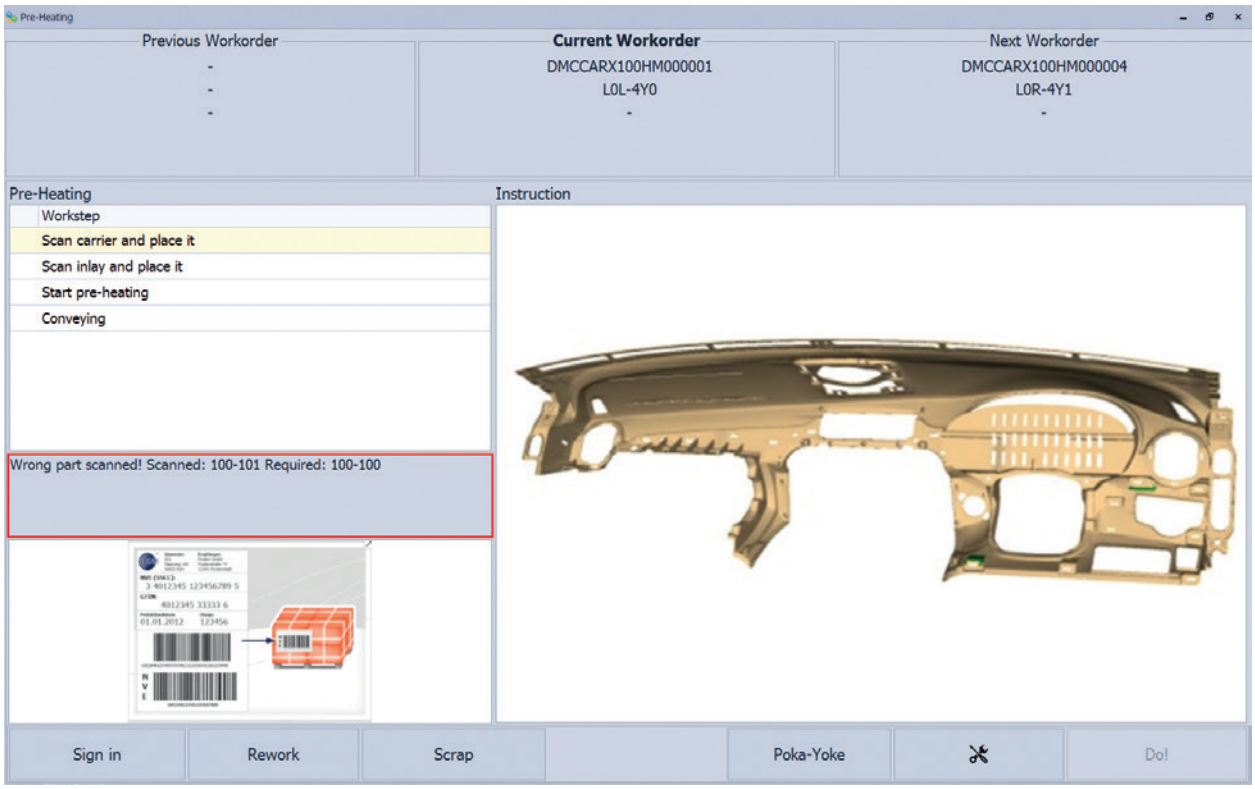
Manual data collection

Providing information to the shop floor

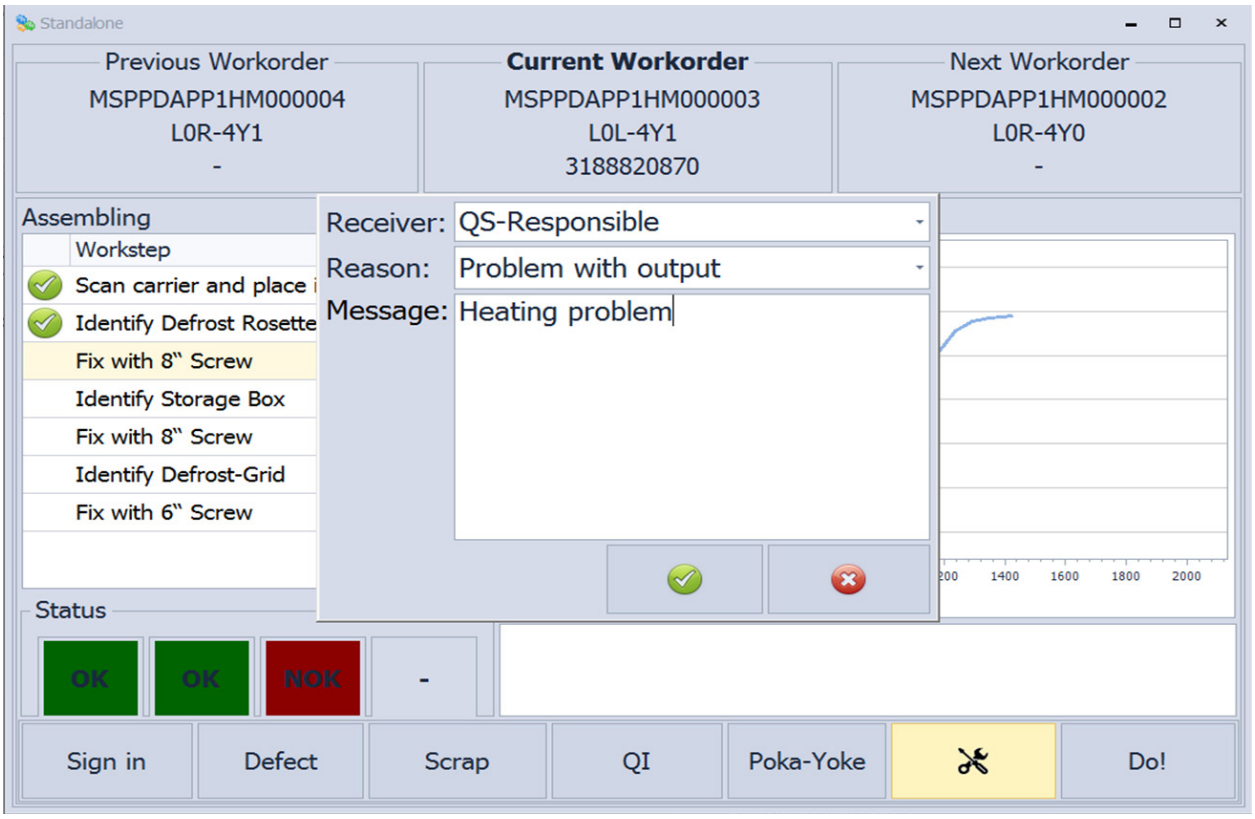
Flexible operator guidance

Example function in MES HYDRA:

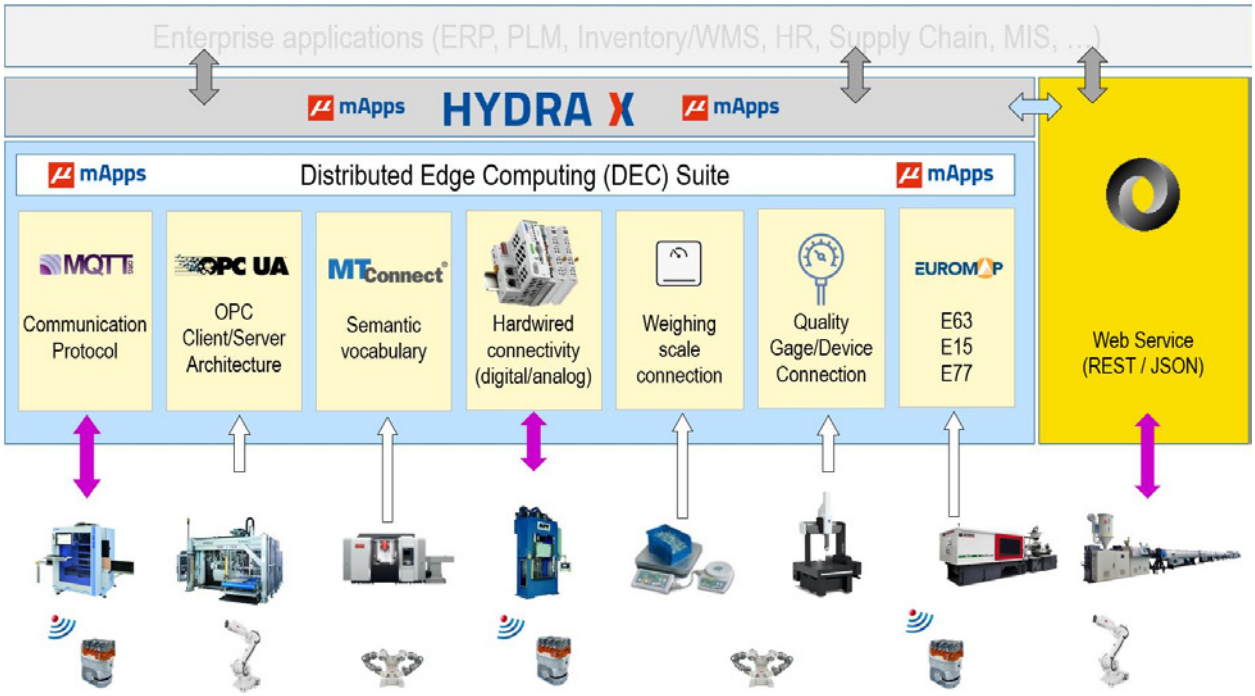
HYDRA X



Example function in MES HYDRA:



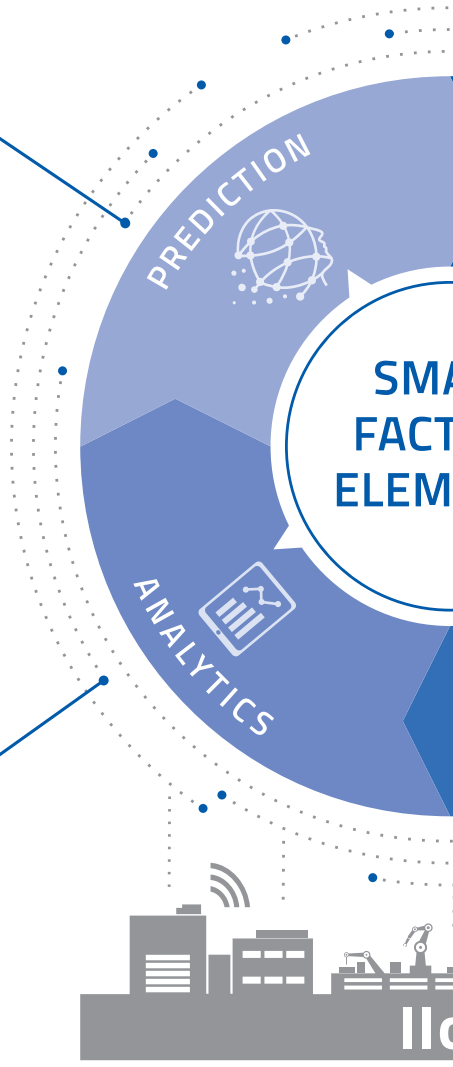
Edge Connectivity with MES HYDRA (connectivity with machines, processes, devices)



Smart Factory Elements

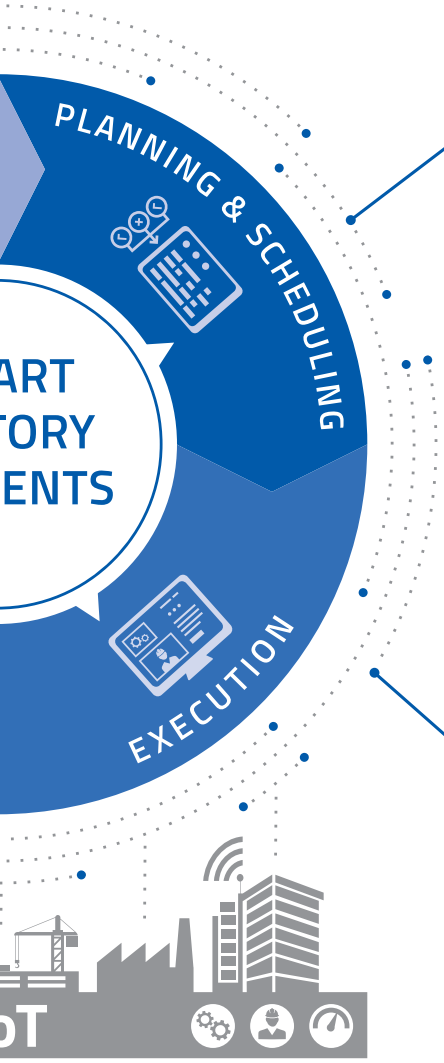
PREDICTION

- Predictive quality
- Predictive maintenance
- Projection of material inventory levels
- Projection of future dates



- KPI's (OEE, NEE, MTBF, MTTR, own KPI's)
- Correlated performance & process analytics
- Statistical Process Control (SPC), FMA
- Root cause analysis
- Self service analytics

ANALYTICS



PLANNING & SCHEDULING

- Order scheduling & finite capacity planning
- Workforce requirement planning
- Technical resources planning
- Material demand planning, changeover planning
- Simulation, inspection planning

- Paperless shop floor information provision
- Digitalized (paperless) manual data collection
- Real-time production control
- Process interlocking
- Event notification to staff

EXECUTION

INDUSTRIAL INTERNET OF THINGS

- Modern IT-based integrations with controls, smart devices
- Hardwired digital & analog connections to machines, sensors
- Manual data collection
- Event-based processes triggering & external system notification
- Flexible operator guidance

BEST PRACTICE SCENARIO

„Smart Factory Elements" applied in one of many possible Smart Factory scenarios:

First, production orders are released by the higher level enterprise systems (ERP, PLM) and transferred to APS & MES applications. Depending on the business nature of the manufacturing company, production orders may already be completely released for production. In some cases, especially in the „high mix & low volume" contract manufacturing environments, it may well be that so-called plan orders or „simulation orders" are first transferred to APS /MES, to simulate the finite capacity impact to the current work-in-progress situation on the shop floor, if they were in fact released , with their desired scheduled dates from the ERP system. Such simulation cycles may be carried out multiple rounds, until the orders are ultimately released as true production orders to be executed. APS is processing these transferred orders, along with information from previous analytics/predictions.

For example , Analytics has shown that article A can be produced 30% more efficiently on machine 1 than on machine 2, and Prediction has revealed that machine 3 might fail with a probability of 75% in the next 24 hours due to worn ball bearings. Therefore, the responsible planner decides to schedule the released production orders for article A on machine 1 and to distribute all others to the remaining machines. At the same time, another employee schedules a maintenance for machine 3 in the next shift, to check the ball bearings and eventually replace them, if necessary.

A few days ago, the QC management decided to change the IPQC sampling scheme for one of the produced articles, so that now every 50th item of all produced items should be subjected to a set of inspections, whereby various attributive and variable quality characteristics must be checked.

These plans then go to applications of the next element : „Execution". The operators at the machines see the pending orders and log them on as soon as the preceding order has been completed. Simultaneously, an inspection order is logged in. Current key figures and order progress are now continuously displayed at the operator terminal. After the first 50 items have been processed, the system signals to the operator the outstanding inspection.

The operator picks the relevant part and checks the specified attributes with a digitally connected caliper and other needed quality gages. The MES collects both the current production data and the results of the quality inspections via applications from the element „IIoT". If the measured values violate the tolerances or the action limits/warning limits, the production is then immediately stopped and a setup technician plus QC engineer is notified to check the settings of the machine and readjust the values if necessary. If the order is completed, the MES can automatically terminate or interrupt it and the next order in the queue will be logged on. During „Execution", integrated event notification functions and process triggers help to achieve a robust and efficient workflow, with an automation degree that is adjusted to the company's needs in their core processes: Visual notifications and buzzers immediately notify operators or supervisors about an ex-

ception or event that requires immediate attention. Additional emails ensure notification to further stakeholders. In the space of „IIoT", while producing the controlled article including serial number and material lot allocation, the integrated MES factory collaboration hub triggers conveyor belts to precisely run only when the current material lot has been completed and shall be carried forward to the next station. Thus, an energy-efficient operation is ensured.

On the second day, the facility engineering department takes care of the scheduled maintenance on machine 3. The employee manually records the rendered maintenance work times with an app on the smartphone. In

the supervisor's office, the shift manager uses an „Analytics" functions to obtain an overview of the productivity and scrap rate of the current shift. Meanwhile, the supervisor analyses the machine malfunctions of the last shift and correlates them with recorded process and quality data. In doing so, the supervisor finds out that machine 5 is also suitable for producing article A with a high efficiency rate. The supervisor discusses the topic during a Digital Production Meeting together with the planners from the „Planning & Scheduling" area. Any new insights from the findings and consequential decisions are subsequently forwarded to the corresponding „Execution" applications. By providing Digital Checklists, shop floor staff will be enabled to sustain their adherence to newly introduced regulations and specifications. The company also engages in „Predictive Quality". The incurring physical process values form the basis for the prediction of the quality of each individual item being produced. If an item is predicted with a high probability of a pass, it will end up in the box for the next work step. Items that are predicted as rejects are immediately sent to the recycling box. All other items are subjected to an additional visual inspection at the material review board (MRB) and then classified as good item or rejects. The results from the „Prediction" applications are transferred directly to the corresponding „Execution" application. To make it all work, different „IIoT" applications connect the machines & processes for automatic data capture and process control, provide input screens for the operator and transmit all required documents and control settings / NC programs the shop floor.

Future

Although many of the examples mentioned seem trivial at first, their integration into the „Smart Factory Elements" model leads to increased application networking. Interlocking of processes becomes configurable and visible. This leads to greater shop floor transparency and agility. It can be achieved with configurable MES and APS systems, such as HYDRA X and FEDRA, on the basis of the MIP. In this area of Manufacturing IT, new innovation drivers are mainly in „Analytics" and „Prediction", to generate further insights and benefits from already available information. Evidently, the „Smart Factory Elements" are a perfect basis for true value - add in the manufacturer's journey towards the Smart Factory in times of Industry 4.0.

MPDV White Paper

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Manufacturing Integration Plattform (MIP)

The functionally linked factory

The autonomous factory

The reactive factory

Smart Factory in four steps

Industry 4.0 needs Horizontal Integration

Controlling production with KPIs

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About

The MPDV Group

MPDV is the market leader for manufacturing IT solutions, with headquarters in Mosbach, Germany. With more than 45 years of manufacturing IT project history, MPDV is an expert within a very wide spectrum of different production environments – both in the discrete manufacturing space as well as in the process manufacturing space. The MPDV Group supports companies in many manufacturing verticals on their way to the Smart Factory. MPDV delivers MES HYDRA, APS FEDRA and the MIP-Manufacturing Integration Platform, for open integration of MPDV solutions and external solutions. Thus, MPDV enables manufacturing companies to streamline their production processes and stay ahead of the competition.

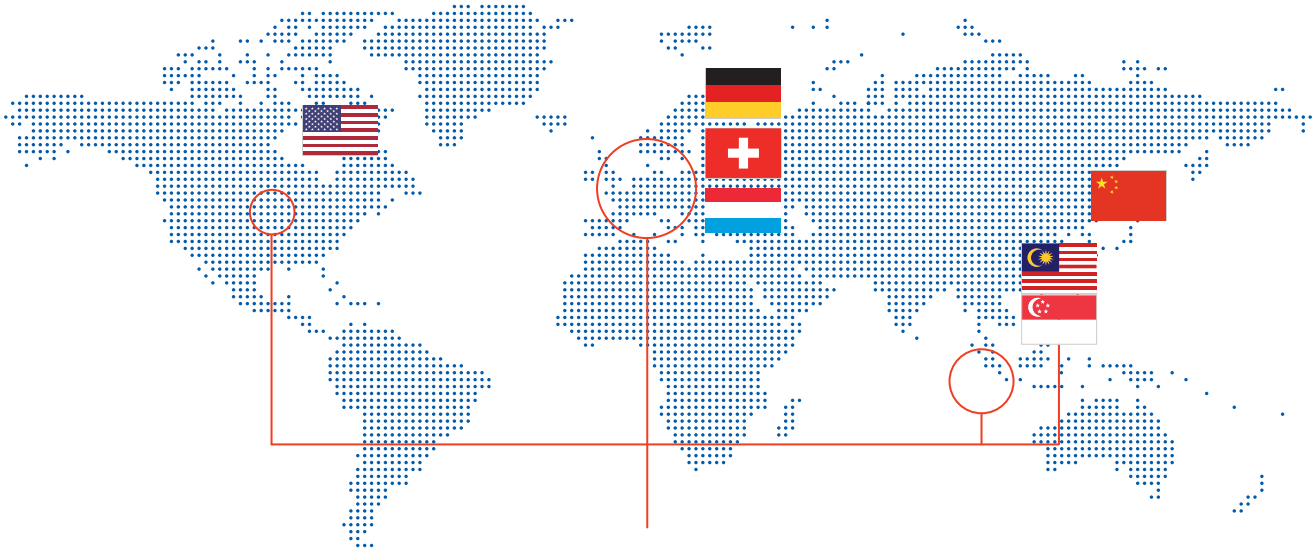
HYDRA X
BUILD YOUR FACTORY SMART

MIP

FEDRA

More than 1,000,000 employees in over 1,500 manufacturing companies worldwide use MPDV s innovative software solutions every day, spanning from well-known MNC's to SME's of various sizes. The MPDV Group employs more than 500 staff in 13 locations in Europe, China, Malaysia, Singapore, Switzerland and USA.

All Asian MPDV locations are wholly owned subsidiaries of the Germany headquarters MPDV Mikrolab GmbH, being fully embedded into the global operations footprint of the MPDV Group, providing local & regional marketing & sales, complete project implementation services (Project Management, Consultancy, Engineering, Training, Solution Development) as well as customer support hotline & maintenance.



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