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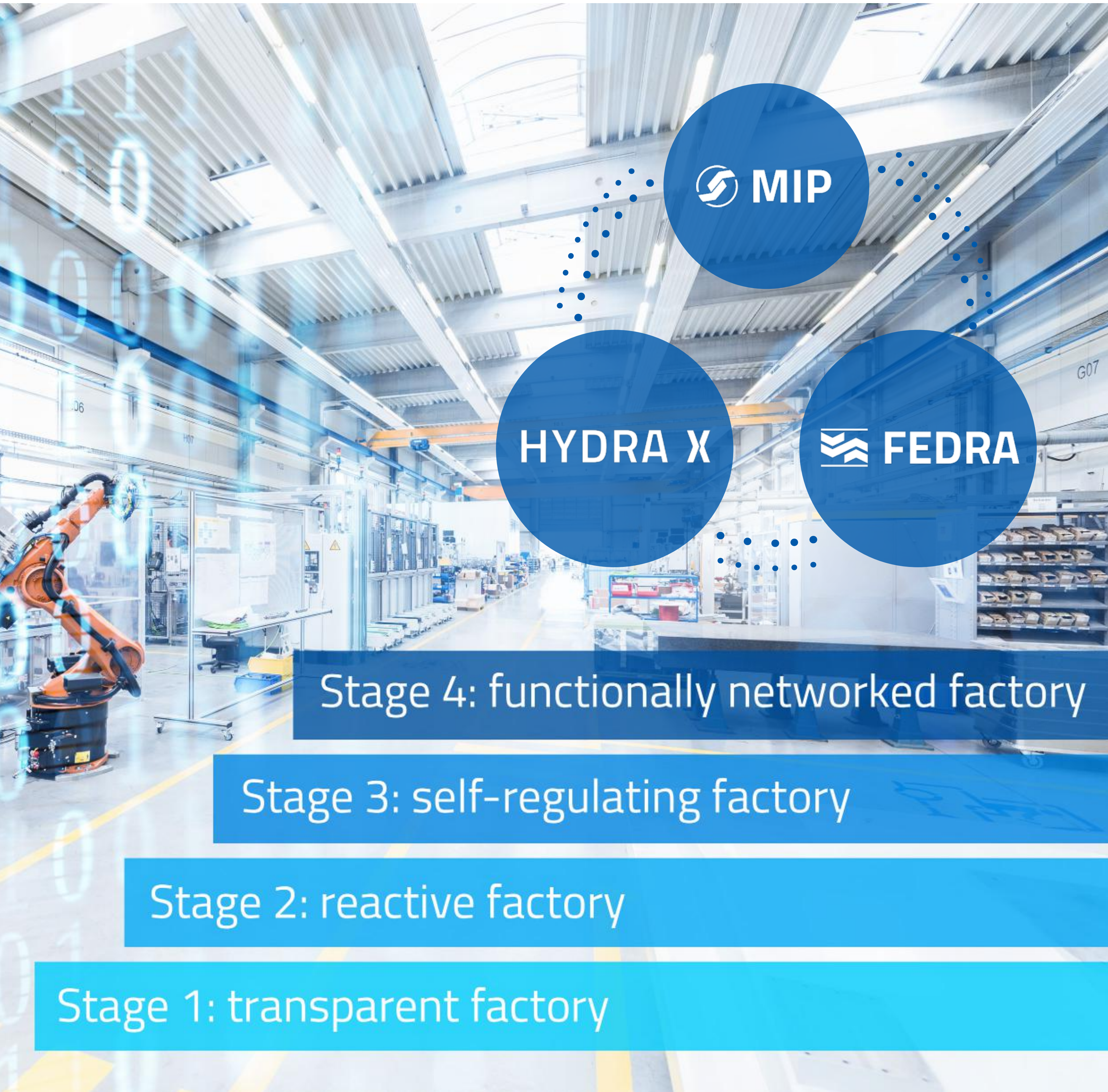
Smart Factory

From the 4-Stage Model to a Control Loop of the Smart Factory



From the 4-Stage Model to a Control Loop of the Smart Factory

MPDV's 4-stage model „Smart Factory" has been established for several years and is used by many manufacturing companies as a benchmark for their own development. Statements such as „We have completed stage 2 for some time now" or „We are moving to stage 4" are no longer uncommon. Now is the time to put the model to the test and bring it in line with the new realities.

Why a fifth white paper on the 4-stage model at all?

Much has happened in industry, both technically and organizationally, since the 4-step model was first publicized in 2016. New technologies and more powerful systems are providing a higher degree of detail in data collection, and demands placed on the manufacturing industry have grown as well. Buzzwords such as „mass customization" or „zero-defect production" do not feature in everyday language, but their meaning has become commonplace and essential for many companies. Short life cycles, small batch sizes and a great product diversity create a level of complexity that companies can only master with powerful IT solutions.

Today, collecting data is no longer considered rocket science. Almost all modern machines provide a wide range of sensor values and status messages via standardized interfaces (e.g. OPC UA). Even older equipment can be easily and inexpensively retrofitted with smart sensors. The problem is not so much getting data, but the challenge is now to decide which data is meaningful.

However, industry has not only evolved in terms of technology. Today, the focus is instead more on processes than on resources. Still, the focus is on resource efficiency, but thinking in terms of processes and workflows has gained in importance. This can be seen particularly in assembly, but also in other areas of manufacturing.

These new insights and perspectives suggest updating the recommended action for manufacturing companies on their way to the Smart Factory. Anyone who doesn't want to know how these new insights came about can skip directly to what's new in the model and the revised recommendations for action - see page 7 (The 4-stage model today). Everyone else can carry on reading.

Short history

A brief look at the history of Industry 4.0 will help to clarify the subject.

The term „Industry 4.0“ was first used in the course of the Hannover Messe 2011. This marked the start of the future project Industry 4.0 or the „Fourth Industrial Revolution“. Over the following years, it was to become apparent that it wasn't a revolution but in fact an evolution.

MPDV responded to the new requirements as early as 2013 with its future concept MES 4.0 - well ahead of other software providers. MPDV specified with the concept a number of requirements from Industry 4.0 for manufacturing IT, which at the time primarily consisted of the Manufacturing Execution System (MES). However, in hindsight, these papers were also relatively theoretical.

In 2016, MPDV succeeded in identifying a tangible way to Industry 4.0 with the 4-stage model „Smart Factory“ that every manufacturing company could follow - no matter what size or industry. Typical applications were assigned to each of the four stages, gradually building on each other and leading the manufacturing company step by step to the Smart Factory.

In 2019, MPDV presented another model at the Hannover Messe: The Smart Factory Elements. The focus here is no longer on the way to the Smart Factory, but on the classification of functions and applications leading to a comprehensible structure. It also mentioned a control loop for the Smart Factory for the first time. In addition, many of the new buzzwords such as IIoT, analytics or prediction were assigned to a clear scope of tasks.

Today, in 2021, it is time to also convert the 4-stage model into a control loop and realize that many things have become simpler. Conversely, demands on the manufacturing industry have increased, so that new tasks have to be incorporated into the model.

As early as 2007, MPDV conducted a kind of I4.0 preliminary study called „Application Park“ together with renowned industry partners for the Hannover Messe. Even though there was no name for it at the time, this integrated and highly networked manufacturing cell reflected many of the ideas that later appeared under the headings Industry 4.0 and Smart Factory.

Looking back - the original 4-stage model

The idea of what qualities a factory would need to have in order to be considered a Smart Factory gave rise to the original 4-stage model. A brief recap will outline the elements of the four stages:

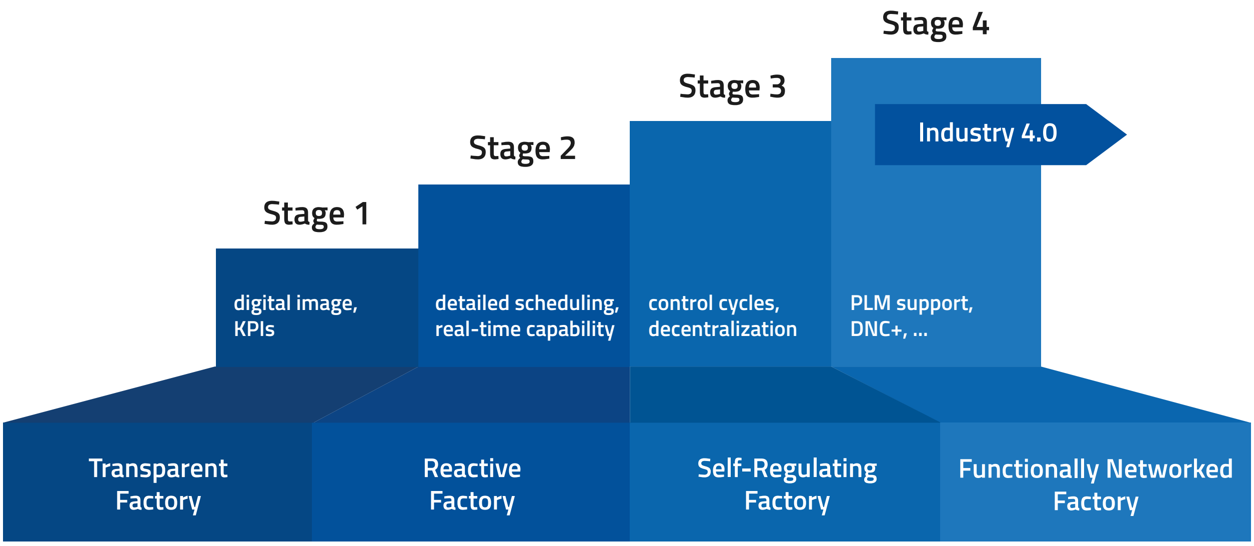


Figure 1: The original 4-stage model

Stage 1 – the transparent factory

The first stage is all about collecting reliable data and visualize it at the right places and in the right form. This also includes the calculation of KPIs.

Stage 2 - the reactive factory

Based on the data collected, it is now possible to improve planning and respond to unexpected disruptions. In addition to the actual detailed planning, the second stage also addresses issues such as personnel scheduling and the inclusion of tooling and maintenance.

Stage 3 – the self-regulating factory

Control loops should be set up in stage 3 to standardize processes and to relieve people from monotonous tasks. Examples include eKanban, automatic forwarding of malfunctions and changed process values. Process-oriented plant management with process interlocking were also a key issue. The aim is that the factory handles everything by itself if things run smoothly. Nevertheless, people play a central role as soon as problems arise.

Stage 4 – the functionally networked factory

At some point, checking production data is no longer sufficient. Data must be correlated - not only including data from the same system, but also from associated disciplines such as quality assurance, intralogistics, or facility management. Gradually, this leads to a complete networking.

In this way, complex interrelationships are created over time: The classic factory becomes a Smart Factory.

Similarities to other models

As already mentioned, we also have new findings from other experts. As a reference, we will take a closer look at two examples: the VDMA guide „Retrofit for Industry 4.0" and the „Industry 4.0 Maturity Index" from Acatech.

VDMA guideline

Although the VDMA guide is essentially about making existing machines and plants fit for Industry 4.0. By the way, this is also the core issue of the first stage of the 4-stage „Smart Factory" model. The so-called „Industry 4.0 Retrofitting Level" increases as data is consistently collected, visualized and used - up to the point of self-regulation. Parallels to MPDV's 4-stage model reach all the way to stage 3 (self-regulating factory). The VDMA guide adds the use of artificial intelligence (AI) to create models based on the collected data by means of machine learning. These models will later help to derive at or take troubleshooting measures. From the requirement to exchange data with business partners, we can identify stage 4 approaches (functionally networked factory). Depending on the use case, this may be equated with a correlation. The VDMA guideline does not deal with the planning aspect, but the continuous condition monitoring also ensures more responsiveness.

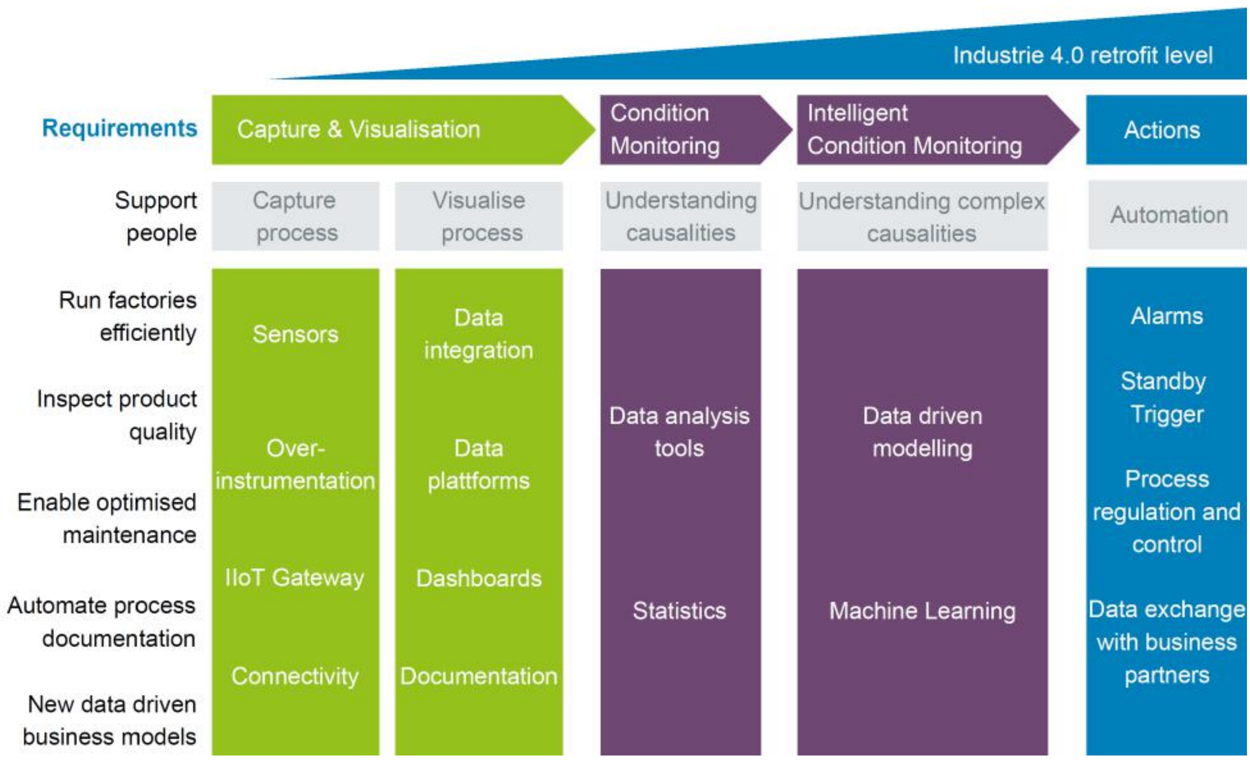


Figure 2: VDMA guideline „Industry 4.0 Retrofitting Level"

Acactech Maturity Index

Acatech divides the way to Industry 4.0 into six development stages and formulates both questions and capabilities to match. Acatech considers data collection itself (level 1 & 2) earlier than Industry 4.0. However, the Industry 4.0 Maturity Index also defines visibility and transparency as important stages. Acatech goes somewhat deeper into technological detail and, from level 4 (transparency), includes the so-called digital shadow in order to assign the collected data to an equivalent in the real world. Level 5 (predictive capacity) and Level 6 (adaptability) correspond in the broadest sense to stage 2 (responsive factory) and stage 3 (self-regulating factory) in the MPDV model „Smart Factory". However, it is not possible to clearly assign the two levels to an equivalent in the MPDV model because the aspects considered in each case overlap.

The Maturity Index even goes one step further and applies the development model not only to manufacturing itself, but to a total of four design fields: Resources, Information Systems, Organizational Structure and Culture. It is clear that this is not just about the use of innovative technologies, but rather about a holistic approach to digital transformation that affects the entire company. With this, Acatech also goes far beyond the scope of MPDV's 4-stage model. Still, aspects can be derived from it that have a direct or indirect impact on manufacturing in the Smart Factory. For example, Acatech proposes a comprehensive system of KPIs to assess the development status - this method can be combined perfectly well with the MPDV model.

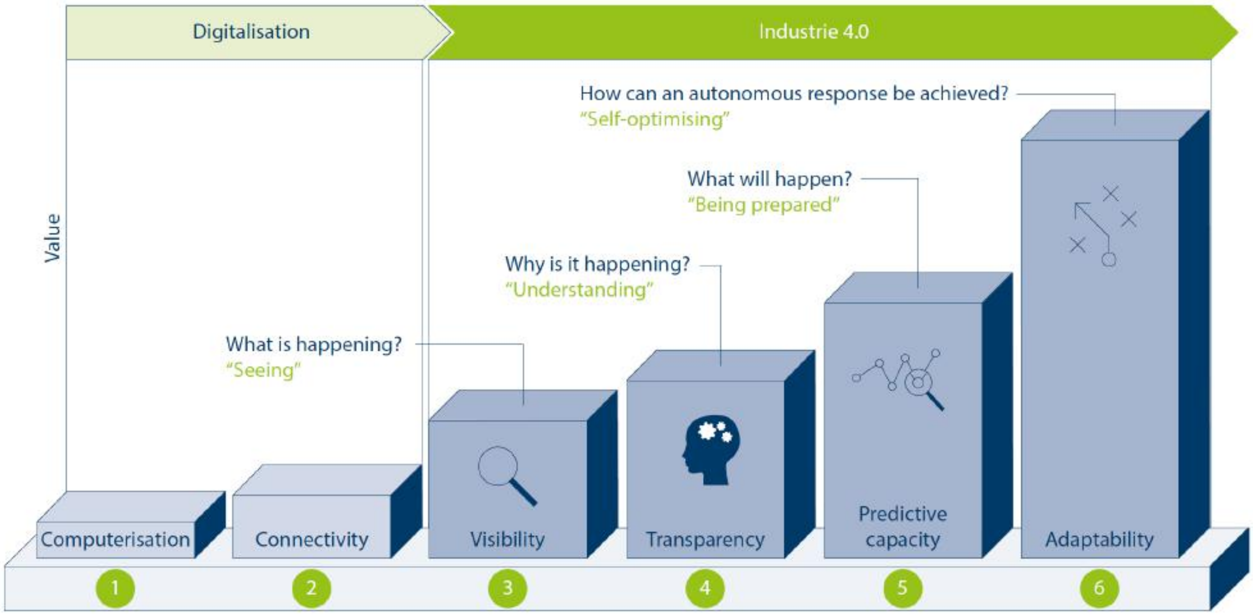


Figure 3: Stages in the Industry 4.0 development path (Source: FIR e. V. at RWTH Aachen University)

The 4-stage model today

But now to what has changed and how the 4-stage Smart Factory model is responding.

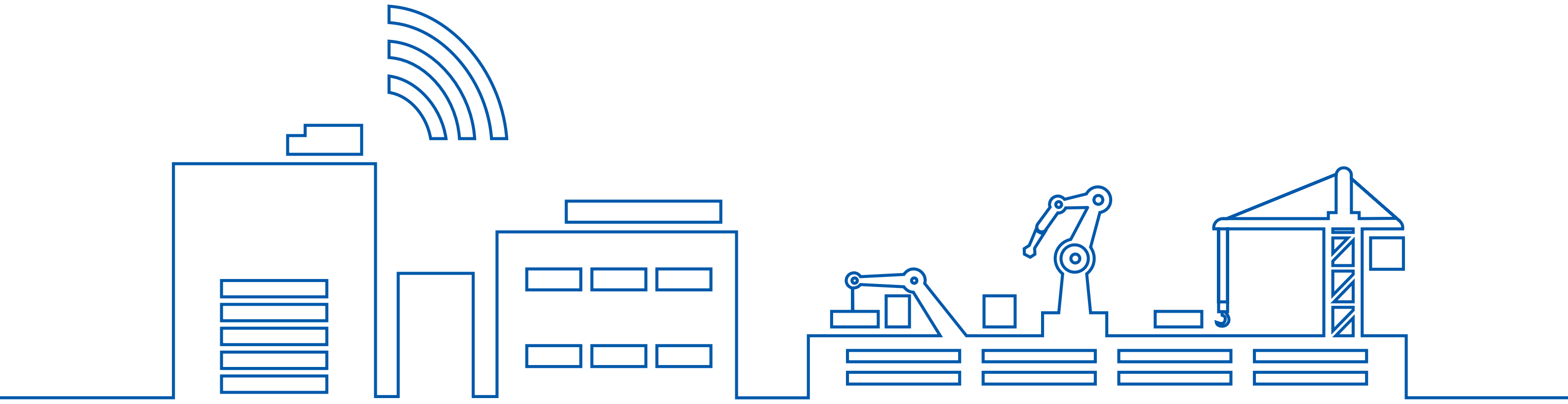
What happens in stage 1?

First of all, the amount and array of data that can be collected have grown significantly. This makes detailed evaluations possible and KPIs are becoming more and more accurate and reliable. However, the mass of data often exceeds the capacity of conventional systems. This is why the updated 4-stage model already envisages the use of artificial intelligence (AI) in stage 1. Machine learning and anomaly detection in particular are suitable methods to cope with the flood of data. For example, AI can determine from a wide array of historical order and machine data in which shifts or under what conditions performance dips or increased scrap rates occur. AI can even identify influencing factors based on the data to help drive optimization. The integration of AI methods in HYDRA X consistently supports the user in making full use of the data available.

What happens in stage 2?

Planning in particular must respond to the ever-increasing complexity. Smaller batch sizes, a greater product diversity and global competitive pressure mean that more workflows must be processed either in parallel or in quick succession. Added constraints and interdependencies complicate the planning process enormously. Artificial intelligence can also help in this discipline. Automatic planning based on reinforcement learning is one example. In the process, AI optimizes the planning, while taking into account all marginal factors and availabilities. MPDV's Advanced Planning and Scheduling System (APS) FEDRA is a powerful planning tool for orders, machines, tools, material, energy and personnel, which also includes AI-based planning.

AI can also assist when it comes to maintenance management by predicting material wear and tear. Predictive maintenance changes from a machine manufacturer issue to an essential aspect of manufacturing IT. The more data is available, the better the Smart Factory can react to prevailing conditions. This means that stage 2 takes precedence over stages 3 and 4, but in terms of a control loop, the order of the stages becomes obsolete anyway.



What happens in stage 3?

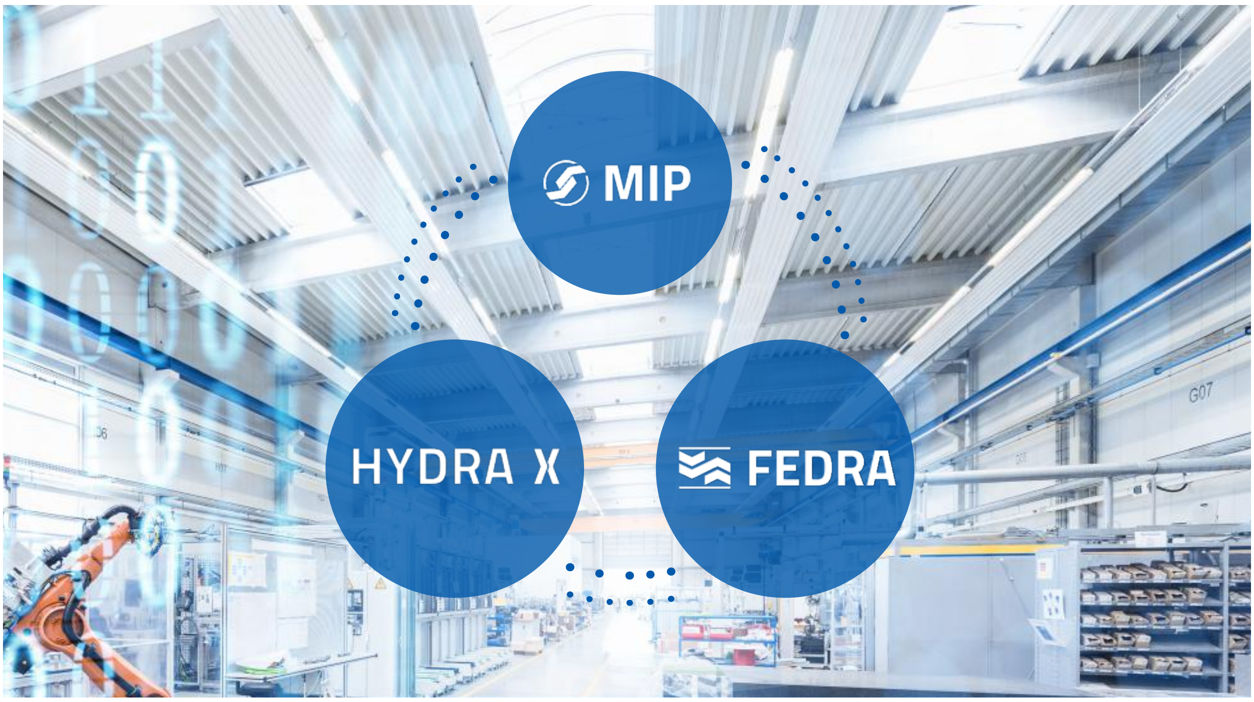
The ability to self-regulate benefits greatly from the increase in performance of IT systems. As a result, it is possible to evaluate much more data, which significantly increases the accuracy of proposed measures. We will at some point be talking about an AI that works alongside the user, monitors everything and immediately detects irregularities. Then users can decide for themselves whether they just want to be informed about the anomaly, or whether AI should suggest measures, or whether the system sorts everything out by itself.

Thinking in terms of processes also leads to better mapping of procedures, which in turn leads to more transparency in the processes. Especially in assembly, modern tools for operator guidance make an essential contribution to optimization. Step-by-step work instructions in the form of text, images and videos are geared precisely to what the operator is currently doing or should be doing. The system prevents actions that are not desired by means of self-regulation. Workpieces, incidentally, are not accepted or forwarded if the current condition does not meet the specifications. Processes must be modeled in order to remain capable of acting in the long term. Mapping by programming is far too costly and rigid. As a result, Assembly Management in HYDRA X includes functions for modeling as well as for process-oriented operator guidance.

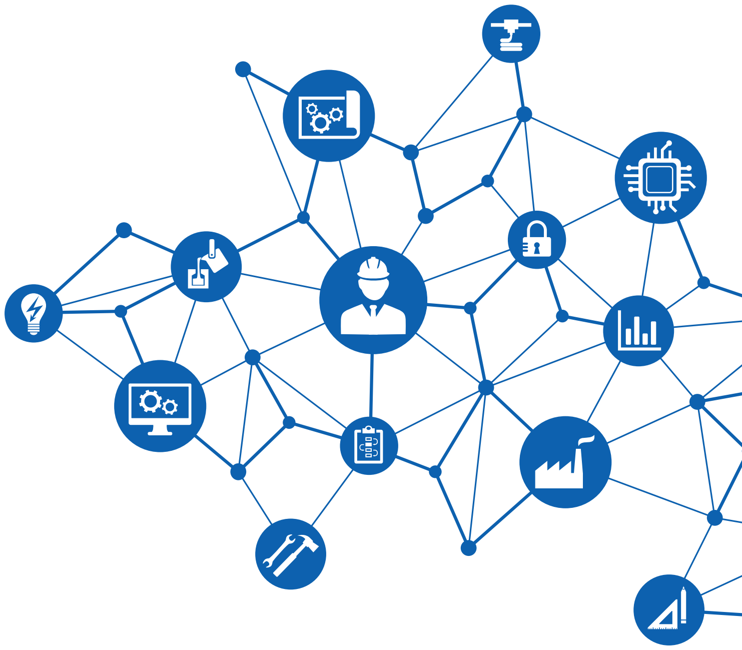
What happens in stage 4?

As indicated elsewhere, networking and the correlation of data are increasingly becoming the basis for transparency, responsiveness and self-regulation. It becomes very clear that the stage model has become a control loop. However, the use of artificial intelligence brings another aspect into play, which the Smart Factory Elements model already shows: Prediction. Using these models, which were created with historical data for real-time data, allows, firstly, their evaluation and, secondly, a prediction of events and outcomes. A good example of this is Predictive Quality. Quality results are predicted on the basis of process data, which in turn can lead to enormous cost savings.

However, in order for networking to progress further, it needs a method of merging data from different sources. The key word here is interoperability. It means that all systems involved have a mutual understanding of data being exchanged and that transmission methods are standardized. An open platform with a semantic information model is ideally suited as a data hub for the Smart Factory. MPDV actually offers such a platform with its Manufacturing Integration Platform (MIP). This platform is the basis to flexibly combine applications from different providers. The common data model and the standardized access to so-called micro services ensure that the MIP can be used as a universal interface. The latest generation of MPDV's HYDRA X and FEDRA solutions already feature a large number of so-called Manufacturing Apps (mApps) that exchange data via the MIP. The ecosystem that has emerged around the MIP is also successively producing new and more mApps. This means that there are no longer any limits to networking. Simultaneously, the new findings from networking form the basis for more transparency: The control loop of the Smart Factory is closing.



Updated call to action



What does this mean for you as a company on the way to the Smart Factory? It's simple: first of all, you can join the updated model at any point. You have probably launched the digital transformation at one point or another. That's perfect - just build on it. Consolidate data and use it to boost the control loop of the Smart Factory. Use existing data to first increase transparency on the shop floor and in the next step increase responsiveness. Wherever possible, set up control loops to allow self-regulation. Use the capacities freed up as a result to drive networking forward. Now you are right in the middle of the Smart Factory control loop.

Finally, a few tips drawn from the experience of many digitization projects:

Think big, start smart

Have vision, but start with the so-called low-hanging fruit. Make sure that digitization is fun for you and your employees. You may even manage to have the savings from one project to largely fund the next one. Loosely based on words by the French writer Antoine de Saint-Exupéry: „If you want to build a ship, don't drum up men to procure wood, distribute tasks and divide up the work, but teach the people the yearning for wide, boundless ocean." Then, when people have understood that a ship is needed on the sea, clear tasks should be distributed, but not before.

Think about the role of people

Despite all the digitization and innovative technologies, people still play a central role. That's why, alongside technological change, there is always a need for measures that embrace people. Even if the term change management sets alarm bells off in many companies, you should get to grips with the idea of preparing your employees for the digital transformation in good time. Ultimately, the goal of the Smart Factory is to relieve people of monotonous routine tasks while giving them control over value creation. Modern manufacturing IT is intended to be a valuable tool for people to master the ever-increasing complexities.

The ball is in your court - take it!

Just start! If you don't start, you will never arrive at your destination. Have courage and do not forget to involve your employees. Never underestimate the expert knowledge of your operators, dispatchers, planners and inspectors.

Once again and most importantly, get started now!

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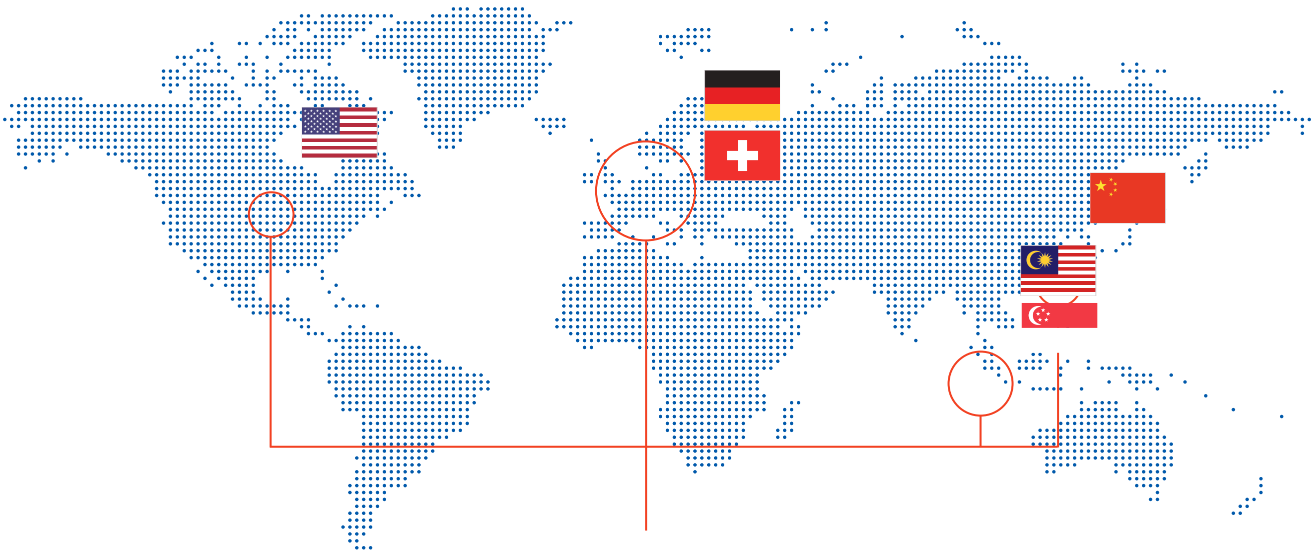
About

MPDV Mikrolab GmbH

headquartered in Mosbach/Germany, is the market leader for IT solutions in the manufacturing sector. With more than 40 years of project experience in the manufacturing environment, MPDV has extensive expertise and supports companies of all sizes on their way to the Smart Factory.

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.

More than 900,000 people in over 1,400 manufacturing companies worldwide use MPDV's innovative software solutions every day. This includes well-known companies from all sectors. The MPDV group employs around 500 people at 13 locations in China, Germany, Luxembourg, Malaysia, Singapore, Switzerland and the USA.



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MPDV Mikrolab GmbH · Römerring 1 · 74821 Mosbach
+49 6261 9209-0 · info@mpdv.com · www.mpdv.com