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# Maturity Steps towards a Digitally Integrated Shop Floor Management

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## Abstract

Shop Floor Management (SFM) is of high importance in manufacturing companies. This article describes the concept of SFM from the viewpoint of industrial practice to develop a model of maturity levels regarding the degree of digital transformation of SFM. This model can not only be used to assess the current maturity of the SFM within a company. It can also be applied to introduce SFM where no structured SFM has been present in the past and develop it step by step to the last level of a digitally integrated SFM of the future. By validating the model on the example of TRUMPF, an insight is given in the status of SFM in the industry.

## Keywords
Shop Floor Management, Digital Transformation, Leadership, Production

## 1. Introduction
Shop Floor Management (SFM) is well established in many companies (Pötters et al. 2018). It links what is physically happening on the shop floor to the sphere of management. To manufacturing companies, it is of such high relevance, that one will find at least elements of shopfloor management in every manufacturing company, even if they are not labeled as SFM. The maturity however will vary.With the progress of digital tools new possibilities and challenges for the practice of SFM arise. The authors report from their own operational shop floor experience and their work as consultants.

### 1.1 Objectives
This paper describes the understanding and requirements for SFM from the perspective of industrial practice. It aims at establishing a framework for the development from first elements to a digitally integrated shop floor management. This framework consists of three stages, that must be passed to arrive at the highest level. By describing a vision for a digitally integrated shopfloor management it aims at sparking ideas for further research.

## 2.1 Definition, goals and concept of shop floor management
Shop floor management can be defined as “leadership on the site of value creation” (VDI 2013, Metternich et al. 2024). In the industry many associate the term shop floor management primarily with SFM-meetings held in

production (Hofmann et al. 2019). While SFM-meetings are a core element of SFM, this understanding falls short of a more global understanding of the function of SFM within production.
The following description of SFM is based on these goals for SFM (cf. Hertle et al. 2017):

- Improvement of operational key figures (quality, costs, delivery performance)
- Structured flow of information, across all levels
- Stabilization, further development of defined standards
- Anchoring of a continuous improvement process, among managers and employees
- Development of employee capabilities through coaching

These goals are not named in their order of relevance, more in the order that they should be addressed during the introduction of SFM. Especially the development of the capabilities of employees is a core goal, but is usually only achieved after other goals are already met.
These goals are reached by the concept of SFM visualized in Figure 1. **Basic guiding principles** of this concept are:

- **Goals** regarding quality, cost and time are clear
- Current **status** regarding quality, cost and time, deviations, problems and possible risks is known
- **Action** is taken by understanding the impact of deviations, agreeing upon and implementing countermeasures.

Starting point are the goals set by the target process, visualized e. g. in a "target house". These goals would typically address goals for improvement (productivity increase, …), broken down through the target development process for each unit (Hoshin Kanri) (Leyendecker and Pötters, 2018). The operational targets (number of products to be produced, delivery dates, …) are the result of production planning. This ensures clarity about the goals as a prerequisite for SFM.
Visual management and operational leadership on site support managers in making decisions about priorities on a daily basis. Transparency regarding the current status enables managers to make the situational decision if the management of deviations or the work on improvements is prioritized. Both deviation management and improvement management make use of the Plan-Do-Check-Act cycle (PDCA). Detected problems or not achieved improvement goals trigger an action and finally the implementation of solutions. Through coaching the employees in using PDCA to solve problems or to do improvement work (e. g. by the Kata method) the manager develops their competencies.

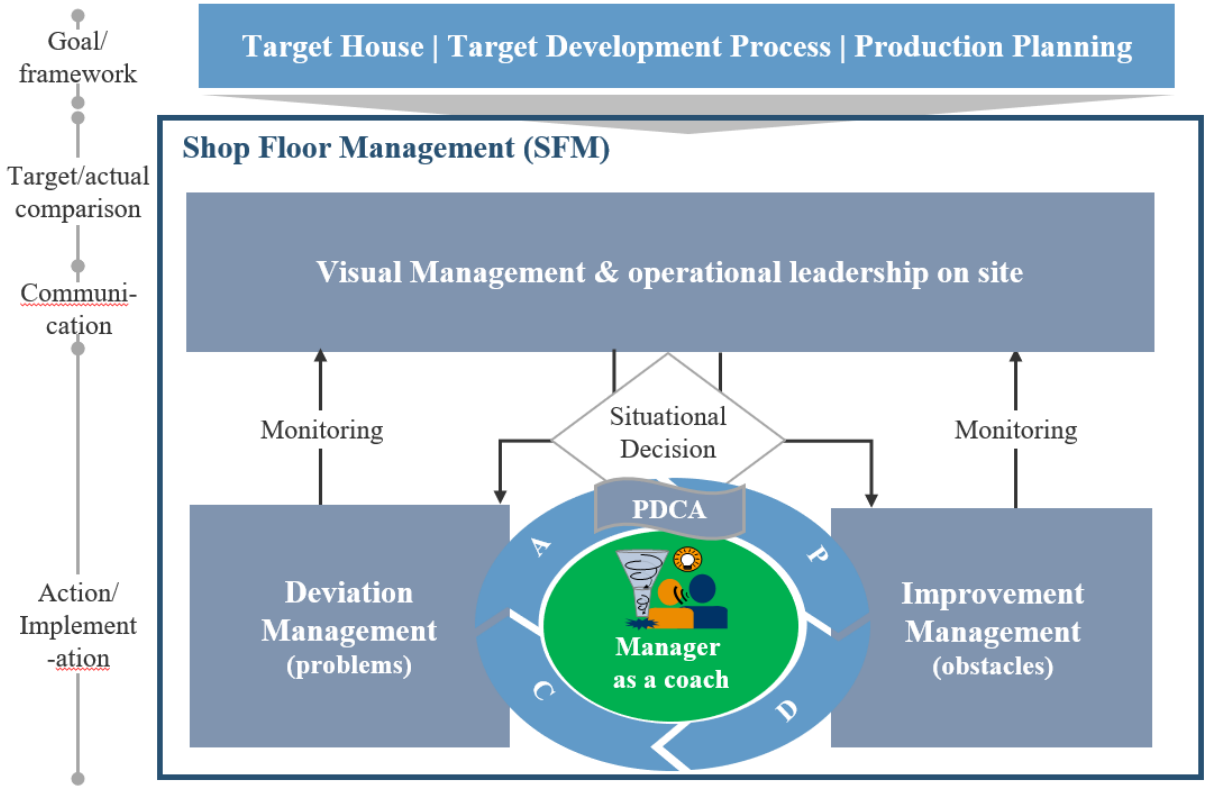


Figure 1. Concept of shop floor management

This concept illustrates the nature of SFM as a support structure for leadership. It focuses not only on the optimization of value adding activities (improvements within the system: processes, etc.), but addresses the development of the culture (improving the system: values, leadership, behavior, …). How this concept is operationalized is described in the next paragraph.

## 2.2 Operationalization of shop floor management through a repeated control loop

The operationalization of shop floor management is centered around the behavior of the manager in different situations as the core element. To improve the system the manager tries to increase collaboration, commitment and reliability. To do this, different roles must be adopted by the manager, ranging from traditional ones like acting as a supervisor and giving clear instructions to newer roles directed at developing the capabilities of employees. These include acting as a trainer, moderator or mentor. These roles should be adopted depending on the situation and the step of the repeated control loop of SFM (see Figure 2).


Figure 2. Operationalization of SFM through a repeated control loop (cf. Bertagnolli 2022, cf. Conrad et al. 2019, cf. Meißner et al. 2018)

### 2.2.1 Info-center and communication

The loop starts with the communication which is taking place in the info-center. The info-center offers a simple visualization of all relevant processes, results and improvement metrics and is located at the point of value creation. It should detect deviations as immediate as possible. The communication takes place in regular meetings that are highly structured regarding agenda, topics, participants etc. The focus is on the current status of production, on goals and tasks. Communication regarding technical details, details of problem solving and planning tasks should be kept outside the meeting to ensure efficiency and relevance to the participants. These meetings are typically stand-ups (no chairs) and short (15-30 minutes). To ensure a fast information flow and escalation through the hierarchy, there is a cascade of meetings starting early in the morning on the first levels and ending typically on the plant manager level.

### 2.2.2 Prioritization

Already during the stand-up-meeting problems and obstacles are prioritized if they need immediate action. This step is very important to avoid overloading the organization with tasks while at the same time ensuring that important issues get addressed.

### 2.2.3 Go and See

Issues that are reported to the manager and that cannot be fully understood by the description given or are very severe will be followed up by a "go and see": going to the place where the issue occurred and observe the situation. To create a shared understanding, often several people are involved, which gives the manager the starting point for coaching employees during problem solving or improvement activities. The concept of go and see goes beyond occasional presence of the manager triggered by problems. The goal is that a lot of time is spend on the shop floor in order to support and develop employees (Kammüller and Guber 2018).

### 2.2.4 Problem solving and improvement

Many issues raised in the stand-up-meeting will require only simple measures to fix them, because the root cause is known. Other issues will require some analysis and a structured PDCA-approach to find the root cause or to create a solution. By mentoring and coaching employees during their problem solving or improvement work the manager can not only support them in building their skills. The manager also gains deeper insights into the details of technical and other processes without having to invest too much time.

### 2.2.5 Process confirmation

To ensure that problem solving and improvement activities have a positive impact, it is necessary to check if the implemented solutions are not only still in place but also effective. The adherence to standards has to be reviewed in regular intervals. This can be supported by T-card boards.
The elements described above can and have been implemented in the past without the use of digital tools. How SFM can be improved further through digital tools is explained in the next paragraph.

## 3. Maturity levels for the development of SFM in terms of digitalization

The maturity levels described here can be used in two ways. Firstly, they can be used to assess the current level and track improvements of SFM. Secondly, they describe stages of development that should be passed through to arrive at the last level of digitally integrated SFM.

The use of digital tools is no goal in itself, their role is to support and enhance SFM (cl. Metternich et al. 2024). Only if their use has positive effects a certain level of maturity is actually achieved. To take this into consideration, the expected positive effects of digital tools are described for each level.

### 3.1 First maturity level of SFM: Analog SFM

Historically the first introductions of a structured SFM were analog. Even if some data was collected in ERP- or MES-systems already, it was transferred manually from the system on the SFM-board. Even today a strong case can be made to start the introduction of SFM this way. Why should any production starting from a low level of SFM not try to start off with a more digital approach right away? As already established, the focus and crucial element of SFM is leadership and behavior. The introduction of SFM requires changes in behavior from both managers and employees, which takes time. The definition of SFM-boards takes time, many iterations and changes. Experiments with different key performance indicators (KPIs), visualizations etc. can be realized on paper with less restrictions and are both faster and cheaper. These experiments also require hardly any digital skills and can be conducted by every manager. Actively designing their own board helps managers to understand SFM better and creates ownership.

Once the SFM has reached a certain level and changes become less frequent, it makes sense to invest time and effort in digital solutions.

### 3.2 Second maturity level of SFM: Digitized SFM

Once SFM is established and has become a daily practice in an organization, the question is raised how these practices could become more efficient. Since large parts of SFM-meeting preparations are concerned with the transfer of information, it is an obvious approach to digitize these information flows in the truest sense of the term by converting analog into digital information. At this level of maturity, the processes and practices of SFM remain mostly unchanged from the previous level.

A typical example would be the replacement of the manual transfer of data from the ERP to the SFM-board by displaying it on a digital dashboard. The benefit from this kind of application of digital solutions are mostly efficiency

gains (e. g. time savings for managers (Grundnig and Meitinger, 2018)). These might be reduced by the fact that at this stage most information is still manually collected and entered into the systems. More transparency is often still linked to more manual collection of data.

New challenges that arise during that phase. Some managers might conclude that because the mere data is available in a digital system, often worldwide, that their presence on the shop floor is no longer necessary. This runs contrary to the concept of SFM as "leadership on the site of value creation". The function of KPIs is to "wave a red flag" by showing deviations and problems. Understanding root causes and coaching employees in problem solving requires the presence of the manager on the shop floor.

Since it is easy in many systems to create a multitude of automatically generated KPIs, there is the danger of losing focus on the main topics in SFM. It is important to limit the number of different KPIs (Meißner et al. 2018). Another effect that can be observed is that SFM creates transparency about the quality of data and the real-time ability of digital systems: after a first glance at the visualization in the meeting it becomes obvious that important information that was received on the shop floor is still missing or the visualized data does not show the actual situation. This raises the topic of better preparation of the meeting by the participants by checking the data upfront and create clarity about the actual situation. Unfortunately, it is not easy during daily business to increase the quality of the data and the real-time ability, which would be the best way forward to the next level.

## 3.2 Third maturity level of SFM: Digitally integrated SFM

This level can best be described as digital transformation, where digital tools change the very nature and abilities of SFM. Transparency is created by the automated collection and processing of data, and digital tools enhance the collaboration between departments and enlarge the scope of SFM. But only with the last step of integrating these approaches in a software framework a fully digitally integrated SFM is achieved.

**Increase in transparency by new data**

An example for an increase in transparency is the automated tracking of the OEE of machines. Not only is a large part of the tracking effort reduced for the employees, but it is also possible to create transparency about issues that are hard to record manually, such as so-called micro-stops. This is also a good example of how digital tools need to be embedded in SFM. The transparency they create calls for actions and the implementation of changes on the shop floor. This way managers can lead and support employees in their improvement efforts.

In assembly, especially if the degree of automation is low, most digital data is still based on input by employees. This creates not only additional effort, but it also requires a high level of discipline to ensure the quality of the data and that it is up to date. With the increase in industrial internet of things applications more automatically generated data should be available in the future.

**Increase transparency by real-time alerts and predictions**

Many tasks that managers must fulfil today require them to be not on the shop floor but somewhere else. Since they are part of the escalation chain they get frequently contacted by employees if problems arise. By then it is often too late to turn the situation around. Trying to limit the effects is all that managers are left with. Real-time alerts enable employees and managers to react earlier to deviations before they become big problems. Instead of just reacting, proactive alerts based on data-mining methods would be desirable (Longard et al. 2020).

**Increase in transparency by working with data**

Data mining (Longard et al. 2020) and artificial intelligence (Chen and Wang 2022) can be used to detect interrelationships that humans are unable to detect by mere visualization of data (Dietrich 2021). Ideally such algorithms work in the background and actively inform the user if any patterns are detected.

**Improvement of collaboration**

Since SFM is strongly focused on production there is always the question of how to involve other organizational units both within and outside the company. Quality issues for example will often require the support of the development or quality department and external suppliers. To involve the employees responsible often works best by being connected to the digital tools in use in their departments.

**Integrated software framework**
The biggest issue today is still the lack of connections between different digital tools like ERP, MES etc. The data from all these systems needs to be integrated and presented in SFM in order to enable managers to make decisions based on the actual status of production. Only with this integration the maturity level of a digitally integrated SFM is achieved. With the integration of the approaches described above, SFM can be improved beyond what is possible without digital tools.

## 4. Validation of the maturity levels through application on TRUMPF

To validate the maturity levels described above, they are applied on TRUMPF. This also illustrates the levels better, gives some insights into the current level of SFM at TRUMPF and is a show case of typical problems.
When trying to assess the current situation the first insight is that the overall picture is very heterogeneous. The levels of digital maturity of the SFM of a group, a department or a plant is not only different from plant to plant, but also within plants or departments.

There is a tendency that the first level of SFM which is between workers and the first line of managers is more analog than the others. In many cases the digital literacy of workers and their access to digital systems is still low. This makes a paper based physical board more accessible. On this level the need for flexibility is also often higher. Certain issues might be tracked in the SFM only for a limited time while they are relevant. Differences between groups (products, processes, …) require different KPIs and visualizations (e. g. machining vs. assembly). The positive effects of the visibility of the information on a physical SFM board right at the place of value creation are high, because the area that is covered is typically smaller than on the higher levels. There are also hybrids where some of the information is on digital screens while other topics are on physical boards.

On the department or plant level many different groups or departments need to be integrated, which leads to a higher degree of standardization in KPIs. This stability makes it easier to implement digital tools. SFM on the department or plant level is mostly on the second maturity level of digitized SFM. Mainly Power BI is used to visualize data from SAP and manually added data (e. g. accidents, attendance). Such no-code or low-code solutions based on standard software are very useful because they can be adapted by many people in the organization and are cheaper than individual solutions (Alt et al. 2019).

Examples for the third level of digitally integrated SFM are still rare. Data acquisition in such a surrounding is generally manual: Most of the production at TRUMPF is manual and complex assembly in small numbers with long assembly times. Methods and tools to create data automatically under such circumstances are a promising field for future research. For collaboration Microsoft Teams or Jira are in use, but are mostly only loosely connected to SFM. While some fragmented examples exist for the connection of such tools, the main challenge remains to have an integrated software framework for all data created and used in production through ERP, MES, Live Location Tracking, and the like.

## 5. Conclusion

While digital tools will not be able to replace SFM because of its inherent nature as “leadership on the site of value creation”, it can be enhanced by digital tools. For the development of digital tools, it is very important to include the perspective of how the tools will be used. In the cases where digital tools are used to collect new data or to analyze existing data, SFM will often be where the results are monitored, and action is taken. When real-time alerts or predictions enable us to be become more proactive, or new tools increase our ability to cooperate, these tools must be integrated in the existing SFM structure in order to become effective.

In summary it can be stated that a SFM that makes no use of digital tools does not use its full potential. On the other hand, digital tools that are not well integrated in SFM are very likely to lack effect and impact on production, because this is where action is taken on a daily basis. Only a close integration of SFM and digital tools in an integrated digital software framework will tap the full potential of both.

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## Biographies

**Max Dinkelmann** is a Senior Inhouse Consultant at TRUMPF SE + Co. KG, working worldwide in production. His focus is on lean management, training and digital transformation in assembly, working on topics ranging from shop floor management, ramp-up of capacities, material supply to target deployment. He was involved in the development of the consulting framework for supporting TRUMPF customers in sheet metal manufacturing (mostly SMEs) in their digital transformation efforts.During five years as a program manager and team lead in clean room production of optical components for EUV lithography he gained operational experience. TRUMPF produces a pulsed high-power $CO_2$ laser system that generates a luminous plasma which emits extremely short-wave radiation at 13.5 nanometers. By exposing substrates to this EUV light, the latest generation of semiconductors are produced. In his doctoral thesis he investigated the use of learning factories to support change management in production. During this time, he was heading the learning factory at the Fraunhofer IPA/IFF of the University of Stuttgart. The learning factory is a highly automated production environment which includes digital tools to enhance learing by doing in industrial engineering. Prior to that he studied Technology Management (mechanical engineering and management) at the University of Stuttgart.

**David Weinmann** is the Head of Inhouse Consulting at TRUMPF SE + Co. KG, he leads the global adoption and enhancement of the lean management system SYNCHRO, boosting productivity and management excellence across the companies functions and subsidiaries. He is an accomplished operations management professional with extensive expertise in implementing lean production systems and process optimization. He previously worked in Management Consulting roles, as well as in the construction machinery industry. In the latter, he served as Head of Operations Strategy, being responsible for the development of global production and manufacturing footprint strategies for a large global enterprise. He spent multiple years in US serving as a Director of Supply Chain, where he spearheaded major operational transformations. He holds a Master of Science in Industrial Engineering from the Center for Advanced Studies at Duale Hochschule Baden-Württemberg.