

56th CIRP Conference on Manufacturing Systems, CIRP CMS '23, South Africa

# Influence of ISO 9001 on the configuration of production planning and control

Simon Hillnhagen<sup>a,\*</sup>, Alexander Mütze<sup>b</sup>, Peter Nyhuis<sup>b</sup>, Matthias Schmidt<sup>a</sup>

<sup>a</sup>Leuphana University of Lüneburg, Institute of Production Technology and Systems, Universitätsallee 1, 21335 Lüneburg, Germany

<sup>b</sup>Leibniz University Hannover, Institute of Production Systems and Logistics, An der Universität 2, 30823 Garbsen, Germany

\* Corresponding author. E-mail address: [simon.hillnhagen@leuphana.de](mailto:simon.hillnhagen@leuphana.de)

## Abstract

The target-oriented configuration of production planning and control (PPC) is a critical factor for companies with increasingly complex supply chains. The logistical performance of companies, which can be measured and expressed, e.g. with the logistical objectives delivery reliability and due-date compliance, suffers above all from the multiple influencing factors of the past years. Especially in the last year, it became apparent that disruptions in material supply due to pandemics or geopolitical crises are causing resource shortages that are posing the industry with ever-new challenges. Since, in many companies, PPC tasks are carried out based on past values, disruptive events have a particularly high impact here. In addition to the external disruptive influences, companies also have to manage the complexity factors of the supply chain, such as a high number of variants or a high degree of customization. The consequence of these circumstances is that companies need corresponding robustness in PPC allowing them to stay productive and competitive. The key factor to establishing high robustness is transparency. Furthermore, the faced uncertainties are often exacerbated by insufficient data situation for the companies' PPC.

Due to the outlined factors in companies, ongoing PPC tasks must be regularly checked for their quality and target conformity to ensure a high logistics performance. For this purpose, the PPC configuration must be carried out systematically and holistically. Therefore, essential PPC frameworks already exist, such as the Hanoverian Supply Chain Model (HaSupMo). Supporting the examination of the company's internal supply chain, the selected procedures for the fulfilment of the PPC tasks serve on the basis of logistical objectives. For this, comprehensive consideration of the PPC tasks must take into account the correct selection of procedures based on individual company needs and data.

At the same time, there is an internationally accepted ISO 9001 standard as a basis for the continuous improvement of all company processes. The described continuous testing and improvement of business processes with a focus on quality management is intended to promote the robustness of the certified companies. Taking a closer look at the contents of ISO 9001 and PPC configuration, structural similarities are noticeable.

This paper aims to examine ISO 9001 for characteristics and interfaces that enable a simplified PPC configuration. In addition, similarities should be identified and systematized, which should be taken into account for future interaction.

© 2023 The Authors. Published by Elsevier B.V.

This is an open access article under the CC BY-NC-ND license (<https://creativecommons.org/licenses/by-nc-nd/4.0>)

Peer-review under responsibility of the scientific committee of the 56th CIRP International Conference on Manufacturing Systems 2023

**Keywords:** PPC Configuration; ISO 9001; Production planning; Production control; Logistical performance

## 1. Introduction

Due to the ever-increasing complexity of supply chains, the configuration of production planning and control (PPC) is becoming increasingly important for manufacturing companies. Especially for make-to-order (m-t-o) manufacturers, a high

degree of transparency within PPC is necessary in order to manage special challenges from a logistical and economic perspective [1]. According to a study from 2021, which was conducted with professionals and managers from the industry, an improvement in process transparency can be achieved mainly through process documentation and standardization,

controlling and tracking measures [2]. Clearly documented and visualized processes promote understanding and acceptance in companies, which can be measured repeatedly in practice in projects [3]. This process transparency forms the basis for company performance indicators, which in turn provide objectives and status data with entries in company-specific Enterprise Resource Planning (ERP) systems [4]. Through detailed process information, the flood of company data generated can be sorted and differentiated before processed data is used, e.g. for planning and control. At the same time, a suitable configuration of PPC is a major success factor for the target-oriented fulfillment of individual company requirements concerning production organization.

At this point, however, the question often arises as to the data and basis on which corporate decisions are made and how the challenges of supply chains can be faced.

ISO 9001 is the most important quality management system (QMS) standard for companies [5]. The standard contributes significantly to the regular monitoring of processes in companies through internal and external audits. Consequently, this standard has a positive influence on business processes with a focus on quality for sustainable entrepreneurial success.

The purpose of this paper is to present the common intersection of the ISO 9001 certification standard and the PPC configuration. Furthermore, the dependencies of good processes of both systems shall be listed and checked for mutual interactions to build up the understanding of a target-oriented PPC configuration.

## 2. Theoretical Background

To ensure that a PPC configuration enables sustainable success for companies, a high level of data consistency is a necessary requirement [6]. From the available company data, key performance indicators (e.g. stock levels, adherence to delivery dates, throughput times, etc.) can be calculated, which serve as a benchmark for the achievement of order processing objectives and thus also show whether the PPC configuration is congruent with the objectives [7]. The higher the data consistency for the determination of performance indicators, the more valuable the statements that can be made using this data. This enables, for example, more precise order placements as well as appropriately determined demand forecasts [8].

On the other side, ISO 9001 aims to integrate a standardized Quality Management System in companies, which requires a transparent and uniform process quality. The background is the creation of comparability between companies, which is determined by transparency in measurability and standardized comparability in the form of performance indicators [9]. Likewise, through e.g. external audits, the goal is to drive continuous improvement in the company, which usually goes hand in hand with an increase in the quality of the company processes. For improvement to be valued, however, this improvement must also be measured in figures and expressed accordingly in the form of a rating [10].

### 2.1. PPC Configuration in an overall context

For a better understanding of PPC configuration, the four levels of production configuration according to Mütze et al. (see Fig. 1) are introduced, which can be differentiated into strategic, structural, tactical and operational levels [11]. Here, a holistic view of the production configuration and thus also the targeted PPC configuration is focused. It also shows how the individual levels are linked to each other (starting with the strategic level up to the operational level). Using a control loop, this conceptual model aims to ensure that the production configuration, and thus also the PPC configuration, is conducive to the achievement of the overall company objectives and set targets [11]. A strategic consideration and the optimally aligned PPC can only be classified as meaningful if the core processes of the company's internal supply chain (procurement, production and shipping) are also defined in a holistic way [12].

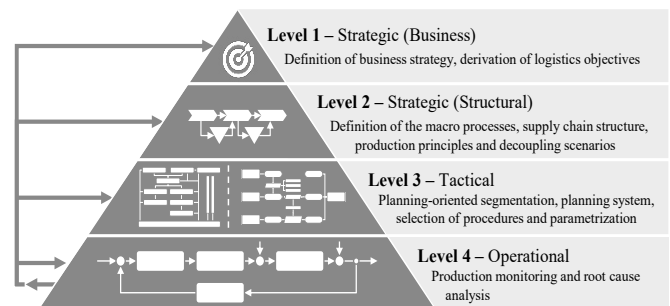


Fig. 1. Four levels of production configuration [11]

### 2.2. Development of ISO 9001

The ISO 9001 standard was fundamentally developed as early as 1979 based on the British Standards Institution with the central idea of standardizing production-related processes for internal and cross-company comparability. On the basis of defined quality requirements, these were to be made measurable by means of objectives and performance indicators in order to be able to express the performance of a company in figures [13]. In addition, the increasing transparency of the company's processes and performance indicators should help managers to make decisions based on sound data. This kind of fact-based decision-making not only serves to improve a transparent corporate culture [10]. Rather, strategic decisions can also be made on the basis of past values and improvement loops of processes and do not have to be made on a hunch due to a lack of data. With ISO 9001, not only the company benefits from the continuous review and improvement of processes (based on the Plan-Do-Check-Act cycle), but also its employees and customers [5,9,14].

### 2.3. ISO 9001 certified Companies in Germany

Since 1987, there have been predecessors of ISO 9001 in Germany, which received its latest version in 2015. In

principle, every company, regardless of the number of employees, the annual turnover and the branch, has the possibility to have such a certification carried out [10]. Despite the fact that this certification option has been in existence for more than 30 years, in 2020 and 2021 there were constantly approx. 50,000 companies in Germany are registered with a valid ISO 9001:2015 certification. 60% (approx. 30,000) of these certified companies from 2021 can be attributed to the extended manufacturing business environment [15]. In relation to this, there were about 2.5 million micro to big businesses in Germany in 2020 (see Table 1). More than 200,000 companies can be attributed to the manufacturing sector. Given that certification for micro businesses is seen as too big of a challenge, this leaves about 75,000 companies in the small to big business sector [16]. This in turn means that currently only 40% of small to big businesses in the manufacturing sector work according to the guidelines of ISO 9001: 2015 and are certified accordingly in Germany.

Table 1. Companies in Germany 2020 [16]

Company size by number *Employees   **Turnover p.a.	Germany (all sectors)	manufacturing sector
Micro businesses (< 9* and < 2 Mio. €**)	2.060.848	125.790
Small businesses (< 49* and < 10 Mio. €**)	370.935	54.662
Medium-sized businesses (< 249* and < 50 Mio. €**)	75.480	17.614
Big businesses (>249* and >50 Mio. €**)	18.994	5.853
<b>Total</b>	<b>2.526.257</b>	<b>203.919</b>

Given that Germany is a country strongly characterized by guidelines, regulations and bureaucracy, it should be noted that ISO 9001 has established itself over the years. However, it can also be deduced from the results that the standard is not found in all sectors and all areas. Nevertheless, a great potential can be identified in the area of ISO 9001 certification for companies in Germany, which has not yet been fully exploited.

### 3. Symbiosis of characteristics from PPC configuration and ISO 9001

Looking at the characteristics and history of the PPC configuration and ISO 9001, there are three essential characteristics be identified that build on each other:

- Process quality
- Data consistency
- Performance indicators

Due to the fact that these three characteristics represent important business processes, a process-oriented approach is the underlying principle here. The more precisely these have been worked out, the more precisely interfaces for data collection can be defined. The quality of this (automatically) generated data thus has a positive effect on data consistency,

which contributes to the basis for the accuracy of the creation of the performance indicators. If the performance indicators are of high quality, decisions of all kinds can be made in a well-founded and transparent manner.

#### 3.1. Process quality

The quality of business processes plays a decisive role not only in ISO 9001. It is precisely the actuality, constant improvement and adaptation of these processes that simultaneously describes a further development of a company. If these are recorded theoretically and put into practice, not only can work and production processes be improved, but the corporate culture can also benefit by involving the employees. At the same time, production planning and control also benefit. Uniform and transparent processes make the effects of decisions at the planning and production control level clear at an early stage. Only good processes provide clarity about interdisciplinary corporate processes, which can thus be pursued strategically and in a targeted manner.

#### 3.2. Data consistency

Company data of the internal supply chain can usually be collected on the basis of input and output factors (data) through material flows in the company. These data often represent higher-level variables such as time, cost and performance. Often, these input and output data are recorded (automatically) via defined interfaces. These can be, for example, input and output variables of machines or defined work and assembly processes. The more consciously a data collection system is defined, the more defined the process is. Depending on the level of automation of the data collection and the number of interfaces, only a company-dependent data consistency can be assumed. However, if the data is regularly checked for accuracy and examined for completeness, this is at the same time a quality feature of the processes in the sense of ISO 9001. But reliable data histories are also essential for planning and forecasting for a company-specific configuration of the PPC [17].

#### 3.3. Performance indicators

Performance indicators provide an important basis for decision-making at management levels, as developments and changes can be mapped in a measurable way. A high level of confidence in indicators is ensured by a high level of data consistency and control processes that regularly put the results to the test. In a continuous improvement process according to ISO 9001, the measurability of change is a fundamental building block. This type of measurability is also indispensable at the planning and control level in order to be able to react to internal and external changes at an early stage.

### 3.4. Interim conclusion

After considering the process-oriented approach of ISO 9001 and the basics of PPC configuration, similarities can be identified. Symbiosis and dependence between ISO 9001 and the PPC configuration can be assumed, since a high degree of overlap can be observed especially at the process level with relation to transparency, quality and consistency. This is because each process should be planned, controlled, monitored and improved in the context of the QMS. If the interaction of the processes works, this results in recurring value creation for the company, the employees and the customers. The process-oriented approach of both procedures determines interfaces and identifies potential for improvement in company processes. Measurable variables are used to control these improvement processes in a target-oriented manner. If a company has already integrated ISO 9001 into its corporate culture in the long term, a comprehensive understanding of processes can be derived, which can be classified as very positive for the configuration of the PPC.

### 3.5. Industrial case study

The presented approaches have been examined in more detail as part of a project with a cooperating make-to-order manufacturer. The company's current PPC was to be put to the test. With the help of the process model according to Hillnhagen et al. (described in [18]), a comparison of the current PPC of the company with the reference model (in this case the PPC of the Hanoverian Supply Chain Model) was to be carried out. This comparison was done qualitatively using existing process descriptions and expert interviews. For this purpose, the interview method of Meuser and Nagel was used [19]. By asking specific questions using an individually developed interview questionnaire, the answers of the participants could be determined and then transcribed. By means of a qualitative examination and allocation of the answers, the answers could be allocated to the 37 individual PPC tasks of the Hanoverian Supply Chain Model reference model. It was frequently possible to assign several statements from different participants to the respective PPC tasks, e.g. sales planning and gross primary requirements planning. Some of the received answers were also descriptions of the PPC tasks that were defined and identified based on the required objectives. This verification aimed to determine a degree of conformance that would match the current PPC tasks with those from the PPC reference model. Some interesting findings were obtained.

A degree of conformity of the PPC tasks of approx. 90% was determined, although the company had never compared the PPC with the reference model HaSupMo before. In addition, extensive business processes and high data quality could always be relied on. Weaknesses were only found in the evaluation of the measured performance indicators.

But especially in the area of planning data, there was a high degree of agreement. There was also increased understanding in the area of capacity management. At the same time,

however, different understandings were found in the area of capacity management, so this form of analysis shows a weakness.

In general, it can be said that PPC tasks can be found in the company, but the structure is different and not bound to a reference model. Nevertheless, there is a very high degree of conformity in the assignment of these tasks, which allows identification of the tasks and thus could in principle allow comparison with a reference model.

Trying to understand why the level of conformance of PPC tasks was unexpectedly high, it was examined which factors could be decisive for this. It was found that the company has had ISO 9001 certification for several years, which is also already embedded in the company culture and daily processes. As a result, well-documented processes could be found, which meant demonstrably good process stability. This process stability in turn has a decisive effect on the better plannability of PPC tasks. In addition, the requirements of ISO 9001 also meant that responsibilities were assigned, which had a positive influence on the transparency between the planning and control entities.

These findings also made it clear that the company already had a good and comprehensive understanding of its processes. The requirements of ISO 9001 were therefore a helpful basis for the analysis of the company's internal PPC. It could thus be certified that the business processes in the sense of ISO 9001 are based on the evaluation of data and information and have been comprehensively documented, which allows adjustments to be made to both configurations of the PPC at any time. However, it could not be determined in the comparison with the cooperation partner that the PPC is sufficiently aligned with the company's internal processes and objectives.

## 4. Summary & Outlook

In this paper, based on the challenge of increasingly complex supply chains and the associated increasing demand for planning and control of these, both the PPC configuration and the ISO 9001 standard were presented with the essential core contents. In the process-oriented approach, intersections were listed in the area of transparency and quality of company processes, which in turn are decisively responsible for continuous improvements in the company. This is because the higher the process quality is to be evaluated, the more specific data interfaces are defined, which in turn, with a high level of data consistency, form the basis for evaluation measures in the form of key figures. The determined performance indicators enable more precise planning and control of company processes, which enable transparent and well-founded decisions, especially at the management level. The case study also confirmed the tendency of positive interaction of both system structures, which seem to form a certain symbiosis due to their mutual influence and dependencies. However, those who practice ISO 9001 well will always automatically move their PPC in the right direction if the company's goals and strategy are adapted to the framework conditions and customer requirements.

In the further course of this research field, the objective will be to find out quantitatively whether and how companies with an integrated and lived ISO 9001 provide a good basis for a needs-based PPC configuration with a PPC reference model. In addition, the individual company needs should also be analyzed with regard to a needs-based PPC configuration. By means of these findings and also the duration of a valid ISO 9001 certification in companies, the quality of the business processes can be evaluated.

## Acknowledgements

The project “Systematic analysis of the effect of production planning and control processes on logistical objectives” leading to this paper is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 434659386.

## References

- [1] Stevenson, M., Hendry, L.C., Kingsman, B.G., 2005. A review of production planning and control: the applicability of key concepts to the make-to-order industry. *International Journal of Production Research* 43 (5), 869–898.
- [2] Bank, L., Luber, M., Theumer, P., Zipfel, A., Kämpfer, T., Hiller, T., Heuer, T., Demke, T., Mundt, C., Köster, N., Janke, T., Maibaum, J., Schmidhuber, M., 2021. PPS-Report 2021: Studienergebnisse, Augsburg.
- [3] Müllerleile, T., Nissen, V., 2014. When Processes Alienate Customers: Towards a Theory of Process Acceptance, in van der Aalst, W., Mylopoulos, J., Rosemann, M., Shaw, M.J., Szyperski, C., Nanopoulos, A., Schmidt, W. (Eds.), *S-BPM ONE - Scientific Research*, vol. 170. Springer International Publishing, Cham, pp. 171–180.
- [4] Jarrar, Y.F., Al-Mudimigh, A., Zairi, M., 2000. ERP implementation critical success factors-the role and impact of business process management, in *Proceedings of the 2000 IEEE International Conference on Management of Innovation and Technology. ICMIT 2000. 'Management in the 21<sup>st</sup> Century' (Cat. No.00EX457). IEEE Conference on Management of Innovation and Technology, Singapore. 12-15 Nov. 2000. IEEE*, pp. 122–127.
- [5] DIN EN ISO 9001 2015 - Qualitätsmanagementsysteme.
- [6] Wiendahl, H.-H., Cieminski, G. von, Wiendahl, H.-P., 2005. Stumbling blocks of PPC: Towards the holistic configuration of PPC systems. *Production Planning & Control* 16 (7), 634–651.
- [7] Nyhuis, P., Münzberg, B., Kennemann, M., 2009. Configuration and regulation of PPC: PPC-Konfiguration und -Steuerung. *Production Engineering. Research and Development (Online)* 3 (3), 287–294.
- [8] Wiendahl, H.-P., Wiendahl, H.-H., 2019. *Betriebsorganisation für Ingenieure*, 9., vollständig überarbeitete Auflage ed. Hanser, München, 1 Online-Ressource (421 Seiten).
- [9] Sfreddo, L.S., Vieira, G.B.B., Vidor, G., Santos, C.H.S., 2021. ISO 9001 based quality management systems and organisational performance: a systematic literature review. *Total Quality Management & Business Excellence* 32 (3-4), 389–409.
- [10] Brugger-Gebhardt, S., 2016. *Die DIN EN ISO 9001:2015 verstehen: Die Norm sicher interpretieren und sinnvoll umsetzen, 2., aktualisierte und überarbeitete Auflage ed. Springer Gabler, Wiesbaden*, 165 pp.
- [11] Mütze, A., Lucht, T., Nyhuis, P., 2022. Logistics-Oriented Production Configuration Using the Example of MRO Service Providers. *IEEE Access* 10, 20328–20344.
- [12] Schmidt, M., Schäfers, P., 2017. The Hanoverian Supply Chain Model: modelling the impact of production planning and control on a supply chain's logistic objectives. *Prod. Eng. Res. Devel.* 11 (4-5), 487–493.
- [13] Wilkinson, G., Dale, B.G., 2002. An examination of the ISO 9001:2000 standard and its influence on the integration of management systems. *Production Planning & Control* 13 (3), 284–297.
- [14] Ingason, H.T., 2015. Best Project Management Practices in the Implementation of an ISO 9001 Quality Management System. *Procedia - Social and Behavioral Sciences* 194, 192–200.
- [15] International Organization for Standardization, 2022. *The ISO Survey of Management System Standard Certifications 2021. International Organization for Standardization.* <https://www.iso.org/committee/54998.html?t=KomURwikWDLiuB1P1c7SjLMLEAgXOA7emZHKGWyn8f3KQUTU3m287NxnPA3Dluxm&view=documents#section-isodocuments-top>. Accessed 29 January 2023.
- [16] Statistisches Bundesamt, 2022. *Ausgewählte Ergebnisse zu kleinen und mittleren Unternehmen in Deutschland: Rechtliche Einheiten 2007-2020. Statistisches Bundesamt.* <https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Unternehmen/Kleine-Unternehmen-Mittlere-Unternehmen/Tabellen/kmu-ergebnisse-xls.html>. Accessed 29 January 2023.
- [17] Hillnhagen, S., Mütze, A., Nyhuis, P., Schmidt, M., 2021. Linked Accomplishment Of Order Management And Production Planning And Control. An Integrated Model-based Approach, in: Herberger, D., Hübner, M. (Eds.), *Proceedings of the Conference on Production Systems and Logistics: CPSL 2021. Institutionelles Repositorium der Leibniz Universität Hannover, Hannover*, pp. 688–698.
- [18] Hillnhagen, S., Schulz, J., Mütze, A., Nyhuis, P., Schmidt, M., 2022. Konfiguration der PPS - Der Weg von der Theorie zur Praxis. *ZWF* 117 (11), 728–732.
- [19] Meuser, M., Nagel, U., 1991. ExpertInneninterviews - vielfach erprobt, wenig bedacht, in: *Qualitativ-empirische Sozialforschung. VS Verlag für Sozialwissenschaften, Wiesbaden*, pp. 441-471