



## THE TOOLS FOR EVALUATING LOGISTICS PROCESSES

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**ABSTRACT. Background:** The growing importance of business process approach and dynamic management is triggered by market expectations for lead time reductions and the pressure for cost cuts. An efficient process management requires measurement and assessment skills. This article is intended to present the tools used in evaluating processes and the way in which they work together under simulated conditions.

**Methods:** The project's Authors believe that a process can be assessed by measuring its attributes: cost, time and quality. An assessment tool has been developed for each of those attributes. For costs - it could be activity based costing, for time - value stream mapping; for quality - statistical process control. Each tool allows for evaluating one of the attributes, any element in the process hierarchy. The methods presented in the paper have been supplemented with process modelling and simulation.

**Results:** In order to show how process assessment tools are combined with process simulation the Authors show a sample process in three versions (serial, parallel and mixed). A variant simulation (using iGrafx software) allows for determining the values of attributes in the entire process based on the data set for its components (activities). In the example under investigation the process variant has no impact on its quality. Process cost and time are affected.

**Conclusions:** The tools for identifying attribute values, in combination with process modelling and simulation, can prove very beneficial when applied in business practice. In the first place they allow for evaluating a process based on the value of the attributes pertaining to its particular activities, which, on the other hand, raises the possibility of process configuration at the design stage. The solution presented in the paper can be developed further with a view to process standardization and best variant recommendation.

**Key words:** process assessment, process modelling, process simulation, process management.

## INTRODUCTION

This paper is intended to present the tools for performance evaluation of processes and linking them to modelling and simulation methods. The Authors of this publication believe that a process can be assessed by measuring its attributes. The publication has added value - it links the evaluation of the attributes pertaining to process elements (activities) with modelling and simulation. Such a solution provides an opportunity for building various process configurations and for evaluating those configurations without putting them in practice.

A growing importance of process approach for business entities and the orientation of those entities on such processes have been the underlying reasons for selecting such an area of research. This phenomenon is driven by market requirements, such as: growing importance of customer service, shortening order lead times, price reductions. To live up to those requirements companies must dynamically change - not only in terms of how they are organized, but how they function - by opting for dynamic management rather than static (structural) management. The management and continuous improvement of processes (their adaptation to meet customer

expectations) requires obtaining control information in order to analyse and evaluate the performance of processes that take place.

Measuring performance efficiency of process is a pivotal issue in both theory and practice. Apart from economic efficiency also other types of efficiency start to gain in importance in this respect (added values generated by various groups of participants). G. Lichocik and A. Sadowski [Lichocik, Sadowski 2013] emphasize the need for taking a broad and holistic view on the performance efficiency of supply chain processes - taking into account all analytic dimensions related to the flow of goods and services. According to those authors a supply chain should be optimum in terms of costs (economic efficiency), functions (reduction of processes, lean - reduction of the number of links to an indispensable minimum), adapting internal processes of the chain's actors to a common objective and ensuring top quality of service (reliable customer-oriented systems).

The use of process modelling and simulation method in research allows for making predictive analyses which look into project variants of processes. According to the Authors process evaluation at its design stage makes a major contribution to the research in the area of process approach.

## PROCESS - DEFINITION

Process orientation requires a broader view on processes within an organization - an organization is a sequence of interleaving processes. Process identification, their evaluation and streamlining allow for increasing the efficiency and the competitive position of an organization [Nowosielski 2007]. What is a process in a business organization? Plenty of definitions can be found in literature.

Table 1. Process definitions  
Tabela 1. Definicje procesu

Author	Definition
PN-EN ISO 9000:2001	A process is a collection of interrelated and interdependent activities, which transform input into output [ISO 9000:2001].
K. Perechuda	A process is a series of parallel, conditional or sequential activities, which transform input resources of the enterprise into output - a product or service [Perechuda 2000].
M. Manganelli, M.M Klein	A process is a series of interrelated activities that lead to transforming process input into a product [Manganelli, Klein 1998].
M. Hammer, J. Champy	A process is a set of activities involving one or more types of input, as a result of which the customer receives a product that is of value for him [Hammer, Champy 1996]
APICS	A planned sequence of activities, operations (mechanical, electrical, chemical, control, test activities) which increases the value-added content of a product or a service [Blackstone, Jonah 2008] .
J. Peppard, P. Rowland	A continuous and regular activity or a sequence of activities taken in a prescribed manner and aimed at achieving a specific result [Peppard, Rowland 1997]
A.G. Rummler, A.P. Brache	A process is a value chain. Each activity participates in creating or producing a product or a service and should hence add value to the preceding activity [Rummler, Brache 2000]

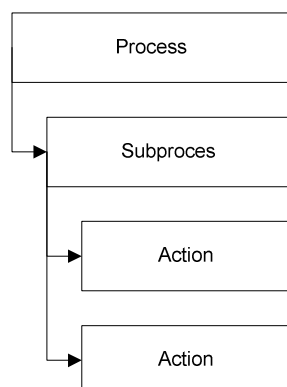
Source: own study

The definition put forward by M. Manganelli and M.M Klein is the most interesting for the Authors. It provides a very concise description of the nature of a process with the focus on product input and output. This definition fits best into the subject matter of this study. Evaluating the process

implementation is undoubtedly linked with the input and output analysis.

The requirements imposed by performance evaluation of processes bring process hierarchy into focus. Processes can be classified into elements called sub-processes and activities.

A sample process hierarchy is presented in the figure 1.



Source: own study based on Nowosielski ed. [2007]

Fig. 1. Process hierarchy  
Rys. 1. Hierarchizacja procesów

Process hierarchy allows for creating their structure. Thus particular process elements (components) can be evaluated and the evaluation results can be translated into a primary process. The Authors of this paper have taken advantage of this property while developing their tool for process evaluation.

## PROCESS EVALUATION

The first step in the evaluation procedure is identifying the process. In the top-down approach consists in identifying strategic, main, core processes in the first place, and building auxiliary processes around them later on. In the bottom-up approach basic activities realized within an organization are identified in the first place, and then pieced together into a whole based on the criterion of functional similarity [Nowosielski 2007].

Process modelling may be a further stage of the process evaluation. Process modelling allows for grasping complex dependencies between individual processes taking place at various organization levels and for arranging processes in a hierarchy. A map is a tool supporting processes modelling. A process map enables the visualisation of activities, evaluating the structuring of the process and its sub-processes and, in consequence, assigning resources to their actual realizations [Lisiecka 2000]. Models can be classified into diagnostic and predictive - based on the nature of the work. Diagnostic models represent the actual situation in an organization. They show "what is". Predictive models describe the desired state of affairs and show what will be or should be [Nowosielski 2007].

According to D. Estampe, S. Lamouri, J.L. Paris, S. Brahim-Djelloul [Estampe et al. 2013] a process performance efficiency may be evaluated from the point of view of the customer and from the point of view of the costs of logistics processes. On top of that the authors of the publication referred to above introduce a set of models measuring the performance of logistics processes.

The Authors of this paper believe that it is of key importance for the process performance evaluation to indicate process attributes that will be evaluated along with the evaluation tools. Cost, time and quality are the process attributes which can be subject to evaluation [Nowosielski 2007]. The first attribute is related to the cost perspective, whereas the remaining two - to the customer perspective. Table 2 presents a list of process attributes along with their evaluation tools.

Table 2. Attributes of the process and tools for their evaluation  
Tabela 2. Atrybuty procesu i narzędzia ich oceny

Process attribute	Attribute description	Tool for evaluation
Cost	assigning process implementation cost as the total of the costs of individual resource consumption activities, required to perform these processes	activity-based costing
Time	one of basic performance indicators of business activity	value stream mapping
Quality	referring to process input	statistical process control

Source: own study

The Authors hold that as regards the tools for process evaluation (in reference to process attributes presented above) prime importance is attached to activity-based costing, which identifies process implementation costs. Activity-based costing means assigning resources to activities and activities to cost objects with the use of resource cost drivers and activity cost drivers. It allows for a precise identification of the implementation costs of a process, sub-process or an activity not only by identifying indirect costs of consumed resources, but first of all by assigning direct costs to processes [Zieliński 2007]. P. Fenies, M. Gourgand, S. Rodier [Fenies et al. 2006] also used activity-based costing in their publication discussing efficiency models of logistics processes, pointing to the advantages of the above mentioned tool.

Value Stream Mapping is a tool used to define and evaluate process lead times. Value stream mapping is a graphic representation of all processes indispensable for delivering a finished product or service to the customer (external or internal). The key metric used for mapping and the key element measured by means of value stream mapping is process lead time. On top of that value stream mapping allows for eliminating muda in the form of processes which add no value from the point of view of the customer [Rother & Shook 1999]. From the process perspective, the value stream mapping tool is used to define process lead times and analyse lead time values from the customer point of view. The map method allows for the correction of processes, intended to enhance value-adding time as viewed from the customer perspective.

The last process subject to evaluation is process quality, which is the extent to which the process output is matched to the expectations held by customers or to the values that have been assumed. The tool used for evaluating this process is Statistical Process Control (SPC). It is a method of monitoring and improving processes over time. There are two types of variations in statistical process control [Woodall 2000]:

- common cause variations - resulting from statistic fluctuations, falling within the specific tolerance range.

- special cause variations - caused by unforeseeable situations occurring in the course of process implementation, falling outside of the prescribed tolerance range.

Statistical process control uses control charts, which capture the values of measured attributes. The nature of the deviation presented in the statistic control chart - common cause or special cause - is of prime importance for the process evaluation. The identification of the causes underlying those variations allows for implementing measures intended to streamline the process implementation and to enhance the quality of its output.

Process simulation and modelling may be the elements linking the value of attributes assigned to particular activities with process performance evaluation. With modern IT tools, processes and phenomena can be modelled and experimented with to an ever-greater extent. Simulation analysis fosters a better understanding of the interdependencies between implementation stages of individual processes. The study of M. and P. Waszczur [Dobrzyński, Waszczur 2012] presents the opportunities for analysing the process in combination with its performance evaluation. The Authors of simulation experiments compared their outcomes with basic process performance indicators and quality assessment as based on SIX Sigma approach. The next chapter discusses the use of simulation in respect of the three process attributes described above.

## **RESEARCH MODEL - PROCESS EVALUATION WITH THE USE OF SIMULATION TOOLS**

This research is intended to identify process attribute values based on the attributes of individual activities with the use of modelling and simulation methods. The evaluation of each of the process attributes is an initial stage of the assessment procedure. To illustrate the capabilities offered by the global process evaluation (the evaluation of all of the process attributes) the discussion of tools has been supplemented with process simulation.

A sample model comprising three activities has been created for cognitive purposes. Three types of material go through a process, referred to as white, green and blue. All of the operations are performed on each material. One employee (resource) is assigned to an operation, which means that only one material

can be assigned to one activity at a time. Input data for the process performance evaluation has been captured using the tools discussed in the previous chapter. Their values are presented in table 3.

Table 3. The input data for the simulation of process  
Tabela 3. Dane wejściowe do symulacji przykładowego procesu

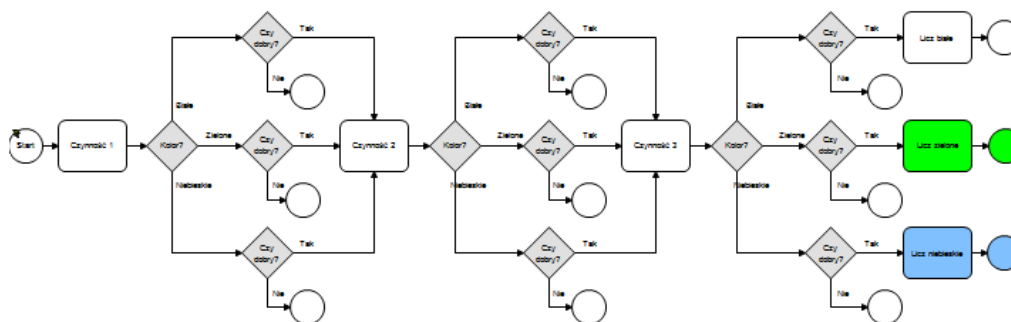
	Cost			Time			Quality		
	Act. 1	Act. 2	Act. 3	Act. 1	Act. 2	Act. 3	Act. 1	Act. 2	Act. 3
<b>Green</b>	PLN 200.00	PLN 100.00	PLN 300.00	2h	1h	4h	98%	96%	97%
<b>White</b>	PLN 500.00	PLN 200.00	PLN 300.00	4h	2h	2h	99%	98%	97%
<b>Blue</b>	PLN 300.00	PLN 400.00	PLN 500.00	3h	3h	3h	99%	99%	99%

Source: Own study

The cost shown in table 3 is the cost of performing a given operation on a defined type of material. The total implementation cost has been increased by the resource (employee) cost, which is PLN 20/h. This cost has not been included in the table, because it has been incurred in the case of both employees working time and waiting time. Process quality (of each of the actions) is understood as reliability, which is the likelihood of obtaining

a result (process/operation output) in compliance with the requirements.

Three process variants have been evaluated: serial (fig. 1), parallel (fig. 2) and mixed (fig. 3). Input consists of a sequence of materials in three colours with a defined order. Input to a process is provided every hour.

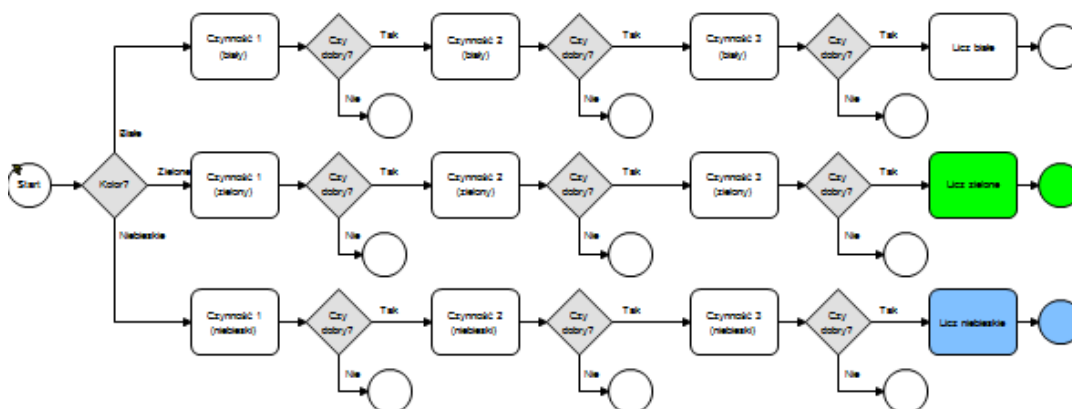


Source: Own study

Fig. 2. A simulation model of process in serial variant  
Rys. 2. Model symulacyjny przykładowego procesu w wariacie szeregowym

A serial variant of the process implementation consists in performing specific operations on materials appearing in the process. A defective operation eliminates the

material from further processing (in all variants). This variant requires 3 resources (employees).

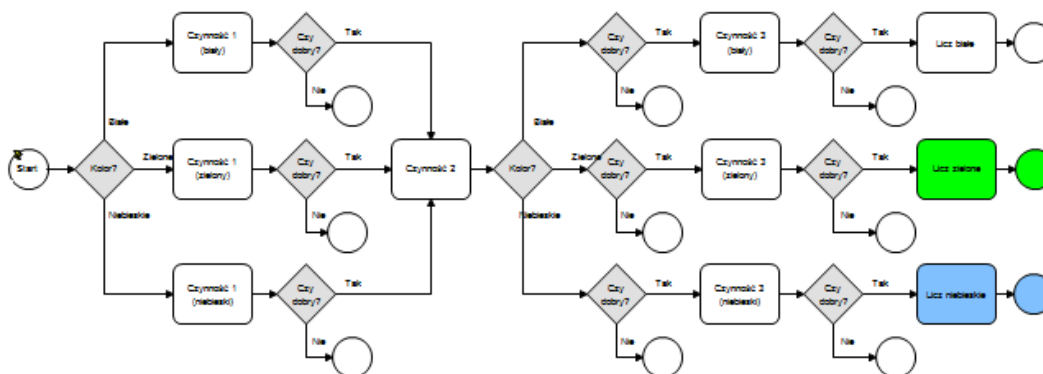


Source: Own study

Fig. 3. A simulation model of process in parallel variant  
Rys. 3. Model symulacyjny przykładowego procesu w wariancie równoległym

Parallel variant consists in allocating a separate set of resources and activities for

each of the material colours. This variant requires 9 resources (employees).



Source: Own study

Fig. 4. A simulation model of process in mix variant  
Rys. 4. Model symulacyjny przykładowego procesu w wariancie mieszanym

A mixed variant is a combination of the two variants presented above. Operation 2 is performed using one resource for all of the colours of materials. This variant requires 7 resources.

incurred on performing the operations and employing the resources (employees) was the lowest in the case of the serial variant. Importantly, the cost incurred on implementing the mixed variant was the highest, which points to the role of bottlenecks in the process. Resources unmatched to one activity lead to significant downtimes regarding other operations, which generates costs. The process quality was the same for each of the variants. This is because reliability was assigned to activities (technological dimension) and colour (material dimension). The quantity of resources does not affect the number of correct items at the output.

Upon the completion of simulations their outcomes have listed based on its attributes (cost, time, quality) and process implementation variants. The outcomes are shown in Table 4.

According to the forecasts, the process lead time and average cycle time (material going through the process) for the parallel variant was the shortest (the shortest waiting time for a free resource). The implementation cost

Table 4. A simulation model of process in mix variant  
Tabela 4. Model symulacyjny przykładowego procesu w wariancie mieszanym

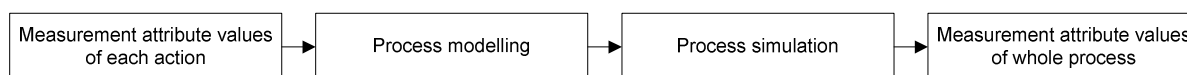
	Serial variant	Parallel variant	Mixed variant
Total cost [PLN]	110 960	115 220	121 120
Time [days]	53,21	22,04	36
Average cycle [days]	25,53	8,41	19,02
Good products White [%]	90,32	90,32	90,32
Good products Blue [%]	92,11	92,11	92,11
Good products Green [%]	87,10	87,10	87,10

Source: Own study

## CONCLUSIONS

The article presents the tools for evaluating processes. They have been proposed for assessing child elements such as activities.

With the application of this method of simulation, the attributes of particular activities have been transformed into the attributes of the entire process. The diagram of the functioning of the tool is presented in fig. 5.



Source: own study

Fig. 5. Diagram of the functioning of tools for logistics processes evaluation  
Rys. 5. Schemat funkcjonowania narzędzia oceny procesów logistycznych

The course of procedure presented in the paper has more advantages than the evaluation of the entire process with the use of three tools. The key advantage is the opportunity for configuring the process from smaller components. It suffices to perform a one-off evaluation of the attributes pertaining to the constituent elements of the process (e.g. particular activities), and then to verify the evaluation of any configuration of this process - through modelling and simulation. Such an activity has profound implications in practice, for it makes business processes much less time- and cost-consuming. Nowadays we can observe a strong tendency to enhance the effectiveness of logistics processes. In view of the above the tool that has been presented allows for evaluating variant forecasts at the design stage, which reduces the need for reconfiguration processes.

A universal metric will be developed in the course of working on the tool for evaluating logistics processes. This metric will comprise the values of particular attributes, including their weights. Such a solution in the field of evaluating performance efficiency of logistics processes was applied by J. Zhangab and W. Tana [Zhangab, Tana 2012] - with the use of the AHP (Analytic Hierarchy Process). The implementation of a universal metric would ensure an objective (according to the selected weights) evaluation of particular configuration variants.

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## NARZĘDZIA OCENY PROCESÓW LOGISTYCZNYCH

**STRESZCZENIE. Wstęp:** Wzrost znaczenia koncepcji podejścia procesowego i zarządzania dynamicznego wynika z oczekiwań rynku związanych ze skracaniem czasu realizacji zamówień oraz presją na obniżenie kosztów. Efektywne zarządzanie procesami wymaga umiejętności ich opomiarowania i oceny. Celem artykułu jest przedstawienie narzędzi wykorzystywanych w ocenie procesów oraz ich współdziałania w warunkach symulacyjnych.

**Metody:** Autorzy prezentują pogląd, że ocena procesu może zachodzić poprzez ocenę jego atrybutów: kosztu, czasu oraz jakości. Dla każdego z tych atrybutów zidentyfikowano narzędzie oceny. Dla kosztu takim rozwiązaniem może być rachunek kosztów działań, dla czasu - mapowanie strumienia wartości, a dla jakości - statystyczna kontrola procesu. Każde z narzędzi pozwala na ocenę jednego z atrybutów, dowolnego elementu w hierarchii procesu. Uzupełnieniem zaprezentowanych metod jest modelowanie i symulacja procesów.



**Wyniki:** Autorzy w celu przedstawienia połączenia narzędzi oceny atrybutów procesu z symulacją procesu prezentują przykładowy proces w trzech wariantach (szeregowym, równoległym oraz mieszanym). Symulacja każdego wariantu (przeprowadzona w środowisku informatycznym iGrafx) pozwala na określenie wartości atrybutów całego procesu na podstawie danych określonych dla jego elementów (czynności). W zaprezentowanym przykładzie wariant procesu nie wpływa na jego jakość. Zmianie podlegają koszt realizacji procesu oraz czas.

**Wnioski:** Zastosowanie zaprezentowanych narzędzi służących do identyfikacji wartości atrybutów procesów oraz powiązanie ich z modelowaniem i symulacją procesów niesie ze sobą wiele korzyści w rzeczywistości biznesowej. Daje przede wszystkim możliwość dokonania oceny procesu na podstawie wartości atrybutów poszczególnych jego czynności co z kolei pozwala na dowolne konfigurowanie procesu na etapie jego projektowania. Opisane rozwiązanie ma może być dalej rozwijane w kierunku standaryzacji oceny procesu i rekomendacji najlepszego jego wariantu.

**Słowa kluczowe:** ocena procesów, modelowanie procesów, symulacja procesów, zarządzanie procesami.

## WERKZEUGE ZUR BEURTEILUNG LOGISTISCHER PROZESSE

**ZUSAMMENFASSUNG. Einleitung:** Der Prozessansatz und das Konzept des dynamischen Managements gewinnen zunehmend an Bedeutung. Dies ergibt sich aus den Erwartungen des Marktes, die Zeit der Auftragsausführung zu reduzieren und aus dem Druck des Marktes, Kosten zu senken. Ein effizientes Prozessmanagement bedarf der Fähigkeit, Prozesse zu messen und zu beurteilen. Dieser Beitrag hat zum Ziel, Werkzeuge, die bei der Beurteilung der Prozesse eingesetzt werden, und deren Zusammenwirken in Simulationsbedingungen zu präsentieren.

**Methoden:** Die Autoren vertreten die Ansicht, dass die Beurteilung des Prozesses durch Beurteilung seiner Attribute, wie etwa Kosten, Zeit und Qualität, erfolgen kann. Für jedes Attribut wurde ein Werkzeug zur Beurteilung identifiziert. Bei Kosten kann das die Kostenrechnung für einzelne Aktivitäten, bei Zeit - die Abbildung des Wertstroms, und bei Qualität - die statistische Kontrolle des Prozesses, sein. Jedes Werkzeug ermöglicht es, ein Attribut, ein beliebiges Element in der Hierarchie des Prozesses, zu beurteilen. Eine Ergänzung zu den präsentierten Methoden stellen die Modellierung und die Simulation der Prozesse dar.

**Ergebnisse:** Um die Verbindung der Werkzeuge zur Beurteilung der Prozessattribute mit der Simulation des Prozesses zu beschreiben, präsentieren die Autoren einen Beispielprozess in drei Varianten (Reihen-, Parallel- und Mischvariante). Die Simulation jeder Variante (im iGrafx durchgeführt) ermöglicht es, den Wert der Attribute des ganzen Prozesses anhand der Daten festzulegen, die für seine Elemente (Aktivitäten) bestimmt wurden. Im angeführten Beispiel hat die Variante des Prozesses keinen Einfluss auf seine Qualität. Es verändern sich jedoch die Kosten der Prozessausführung und die Zeit.

**Fazit:** Die Anwendung der präsentierten Werkzeuge zur Identifizierung der Attributwerte und ihre Verbindung mit der Modellierung und Simulation der Prozesse bringt Nutzen für die Geschäftstätigkeit. Sie bietet insbesondere die Möglichkeit, den Prozess anhand der Attributwerte der jeweiligen Aktivitäten zu beurteilen, was wiederum ermöglicht, den Prozess auf jeder Stufe seiner Gestaltung beliebig zu konfigurieren. Die beschriebene Lösung kann in Richtung der Standardisierung der Prozessbeurteilung und Empfehlung der besten Variante weiter entwickelt werden.

**Codewörter:** Prozessbeurteilung, Prozessmodellierung, Prozesssimulation, Prozessverwaltung.

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