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Transformation Of Change Requests Into IT-Modules of ERP- and ME-Systems

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Abstract

Industrial practice shows a strong trend towards digitalization. It is not only economic crises, such as those triggered by Covid-19, that are reinforcing this trend. It is also the entrepreneurial urge to fulfill customer wishes in the best possible way and to adapt to new requirements as quickly as possible. Due to the advancing digitalization, the role of business application systems in manufacturing companies is therefore becoming increasingly important. The data processed in IT-Systems represent a great potential, especially for the evaluation of change requests in production. Through efficient change management, companies can record and process changes quickly. However, the necessary data basis to decide on existing change requests is still hardly used. Existing IT-Systems for change management coordinate the processing of change requests, but do not relate to data of operational application systems such as Enterprise-Resource-Planning. Therefore, a conceptual approach is required for the evaluation of change requests. This approach is based on an objective recording system that enables the transformation from the change description to an evaluation space. The paper presents an approach for the systematic transfer of requirement characteristics into the world of operational IT-Systems.

Keywords

Change Request; Change Management; ERP; Evaluation

1. Introduction

1.1 Initial situation

The industrial revolutions have brought many changes within production and markets. The international orientation of many companies leads to the exploitation of new markets and new customer segments. The exploitation of such markets is linked to changing competitive situations with competitors. New markets can also show enormous differences in customer requirements. In addition, the market situation can change more rapidly than ever before due to advancing digitalization [1]. The customers who consume the products and services are constantly creating new requirements. According to the Kano model, the requirements of users are continually shifting. The model clearly shows how old products and product features are considered obsolete after a certain time and are taken for granted by the customer. [2] These trends in the development of markets have accelerated significantly in recent years. Digitization promotes the exchange of information both on the customer side and on the side of the manufacturers of products and services. The customer and his requirements for a product define the market success and thus the competitiveness of a company. This is why customer centricity is more important than ever before. [3]

These developments have led to enormous pressure on product development and production cycles. Time is elementary for the development of competitive advantages. Therefore, the product development times are shortened. This is to ensure that customer requirements are fulfilled. [4] The difference between customer requirements and product functions must be kept as small as possible. The shortening of development times for new products goes hand in hand with a shortening of the utilization phase and thus a shortening of the product life cycle. [5]

1.2 Problem definition and motivation

The initial situation explained in the previous section leads to major problems for manufacturers. Highly competitive markets lead to increased pressure on companies to meet customer requirements in the best possible way. This leads to a high frequency of changes. The changes can affect the product directly or the structures that are used for manufacturing [6]. Looking at the manufacturing industry, a study from Germany attributed a significant role to change management for the 2020s [7]. One of the reasons for this is the high complexity of change management. It is a holistic approach that takes into account correlations between the areas of organization, technology, process and product [8] [9]. Moreover, this correlation must be considered in the digital representations of production. In manufacturing advancing digitization is continuously generating data streams, which are coordinated using operational application systems. It is particularly the use of data that characterizes the production and value creation processes [10]. In terms of change management, such consistent use of data is currently not evident. The systems established on the market focus on the management of change. This means that the handling of a change request is prioritized, and the systems rarely have interfaces to the operational application systems of the production and development department. Consequently, the data generated by the production system is not directly integrated into the management process of a change. The lack of a definition for a standardized change request evaluation process is one of the reasons for the insufficient integration. A comparison with change management norms and standards shows that the evaluation process is mentioned by most of them but is not specified in greater detail. The reference process of change management of the German Association of the Automotive Industry serves as an example at this point. This is explained in the associated guideline (VDA 4965) and is shown in Figure 1. It is noticeable that the assigned reference step does not contain any associated process descriptions for the evaluation process [11] [12]. This lack of integration and consideration of operational application systems in change management standards and norms is the reason for the missing integration into change management systems. This means that the people who decide whether to accept or reject a change request must rely on their expertise or search for information in the operational application systems to take it into account.

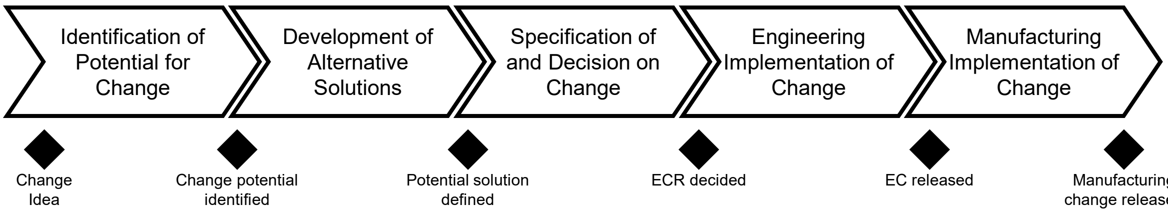

Figure 1: Engineering Change Management reference process [11]

The aim of the present approach is therefore to demonstrate a way in which change requests can be made evaluable with the help of operational application systems in use. This requires an approach that enables a connection between an existing change request and functions of the operational application systems to comply with the holistic approach in the sense of change management. For this purpose, first the objective recording of a change request is explained. It is followed by a concept for establishing a connection to the IT systems based on the recorded characteristics of a change request. For this purpose, an approach is presented that uses the Aachen-PPS-model as a reference system to link the recorded characteristics with the functions of the operational application systems. In conclusion the results are discussed and further need of research is highlighted.

2. Conception and detailing of the solution approach

The focus of the following sections is to integrate functions of operational application systems into the reference process of change management. To evaluate a change request the decision-relevant information must be established. This information can be found within an Enterprise-Resource-Planning System (ERP) and Manufacturing-Execution-System (MES) [10].

2.1 Neutral objective recording of changes

The handling of changes is usually regulated internally. In most cases, it is precisely defined according to which specifications a request must be recorded and in which order it must be processed in accordance with internal change management [8] [11]. The analysis of common standards shows a wide use of evaluation categories. In industrial practice, a combination of descriptive text in combination with defined parameters (mass, costs, cycle time, etc.) is often used for data recording. In order to standardize the recording process, companies have created templates to enable standardized recording. [13] An analog recording is the most frequently used type of recording. Change management systems increase the degree of digitization at this point by digitally representing the recording documents. In change recording, it is common to estimate effects, which is why a subjective value is the basis of the recording. This subjectivity cannot be corrected in the subsequent evaluation process. Therefore, a systematic approach is required to carry out a fact-based evaluation after the recording. For the objective recording of a change request, the approach developed by KÜLSCHBACH ET AL. is used. This uses the methodology of the characteristic schema to generate standardized description characteristics and can be seen in Figure 2 [14]. The approach is useful for executing a transformation due his standardized characteristic values which avoid textual descriptions by users. It excludes the subjective interpretation. This enables a consistent transformation.

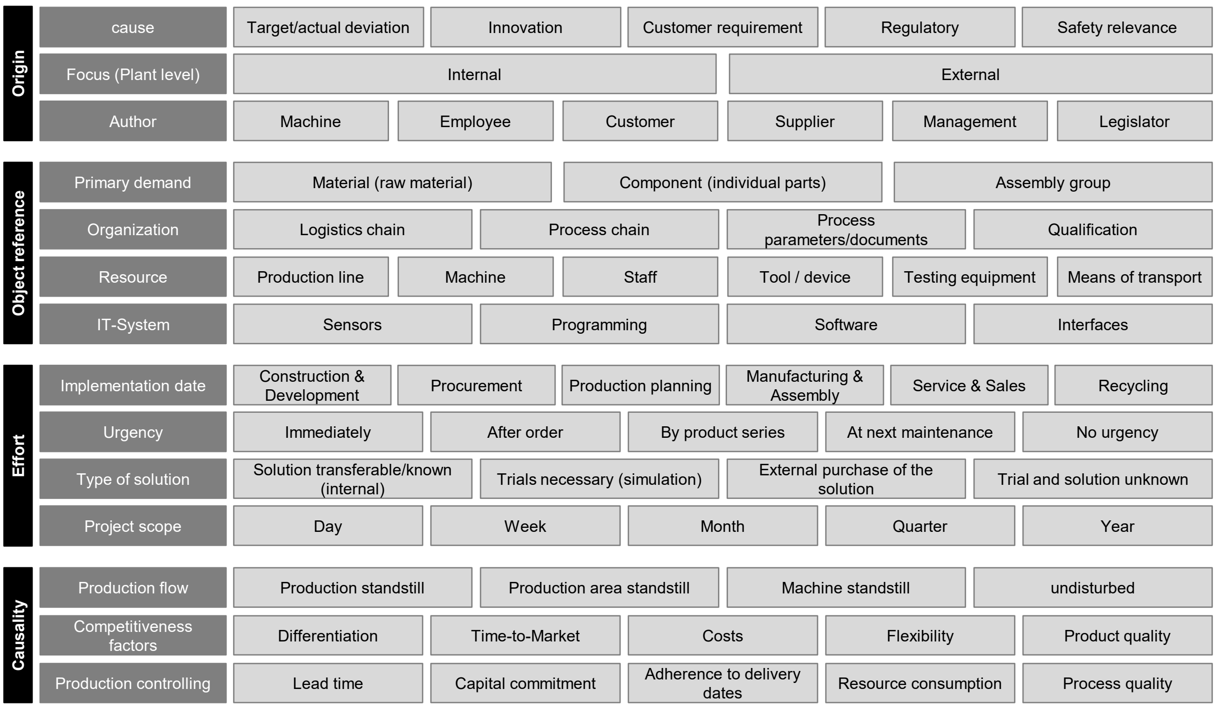

Figure 2: Characteristics schema for change request recording [14]

2.2 Transformation

The change management systems do not provide a direct link to facts or information but focus, as described in the introduction, on the pure management and coordination of change requests. This creates a gap in the information flow, which makes the evaluation even more difficult and is not considered user-friendly. To be able to perform a transformation from the level of the characteristic schema according to KÜLSCHBACH ET AL. a process-related reference is required. Operational application systems are characterized by their support function within order processing. Therefore, the processes of order processing can be understood as a connecting element between the characteristic attributes of the characteristic schema and the functions of the operational application systems. The elaborations of SCHUH ET AL. offer a suitable framework for this, as the tasks of production planning and control are defined as a descriptive reference model [15]. The analysis of the publications of SCHUH ET AL. shows a deficit in the integration of IT-Systems. The wide distribution and use of the approach therefore shows the need for research [16] [17] [18].

Tasks of the Aachen PPS model

from \ to	Core tasks: Production program planning			Core tasks: Production requirements planning						Core tasks: In-house production planning and control						Core tasks: External procurement planning and control			
	Sales planning	Primary demand planning	Resource rough planning	Gross Secondary Demand Determination	Net Secondary Demand Determination	Procurement type allocation	Lead time scheduling	Capacity demand determination	Capacity coordination	Lot sizing	Fine scheduling	Resource fine planning	Sequencing	Availability check	Order release	Purchase order calculation	Request for quotation/evaluation	Supplier selection	Order release
Origin – Cause																			
Target/actual deviation							●	●		●	●	●	●	●	●	●		●	
Innovation	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Customer requirement	●	●				●		●									●	●	
Regulatory	●																	●	
Safety relevance	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Origin – Focus (Plant level)																			
Internal	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
External																			
Origin – Author																			
Machine			●				●	●	●	●	●	●	●	●					
Employee			●					●	●		●	●	●	●					●
Customer	●	●													●	●	●		
Supplier						●									●	●	●		●
Management			●			●	●			●			●		●	●			
Legislator	●		●			●									●		●	●	

from \ to	Network tasks: Network config.		Network tasks: Network Sales Planning		Network tasks: Network Demand Planning			Cross-sectional tasks: Order management			Cross-sectional tasks: Inventory management					Cross-sectional tasks: Con-trolling		Data management	
	Product program planning	Network design	Sales volume determination	Sales volume consolidation	Network Capacity Planning	Network Demand Allocation	Network Procurement Planning	Quotation processing	Order processing	Order coordination	Inventory planning	Inventory analysis	Warehouse management	Inventory accounting	Batch management	Information processing	Measures derivation	Master data	Transaction data
Origin – Cause																			
Target/actual deviation									●	●	●			●		●			●
Innovation			●	●	●		●				●							●	●
Customer requirement	●		●		●		●	●	●		●		●						
Regulatory	●	●						●	●				●		●		●	●	
Safety relevance	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Origin – Focus (Plant level)																			
Internal								●	●	●	●	●	●	●	●	●	●	●	●
External	●	●	●	●	●	●	●												
Origin – Author																			
Machine					●					●					●	●	●	●	●
Employee					●			●	●	●				●		●	●	●	●
Customer	●		●			●		●	●					●	●			●	●
Supplier		●					●				●		●	●	●			●	●
Management	●	●		●	●		●				●	●	●			●	●	●	●
Legislator	●						●						●		●			●	

Figure 3:Transformation matrix for characteristics schema to PPS tasks – domain *Origin*

For connecting IT-modules to the tasks of production planning and control a two-stage procedure was selected for the transformation. This is based on the TRIZ methodology according to ALTSHULLER, which is used to solve complex tasks. A concrete problem is transformed into a solution space and then concretized. This is necessary because the direct solution path from specific problem to specific solution is too complex. [19] This is also valid for a transformation from the characteristic schema to IT-modules and functions. Therefore, a generally valid reference point for the assignment of characteristic attributes to IT-modules and functions is needed. This reference is given by the tasks of the Aachener-PPS-model according to SCHUH ET AL [15]. Based on these elaborations, a logical derivation of the assignments was developed in the first step of the transformation. These correlations between characteristic attributes of the schema from KÜLSCHBACH ET AL and tasks from the Aachener-PPS-model were made based on an analysis of content description. In addition, the correlations were validated in discussions with experts from industrial practice. These experts were representatives from different ERP providers like Asseco Solutions; Comarch, SAP® and proALPHA. Figure 3 shows the correlations between the characteristic attributes of the domain *Origin* (represented within rows) and the tasks of production planning and control (represented by columns). As an example, an excerpt of the correlations of the characteristic attribute *Customer* from the *Author* domain will be explained. The customer as the source of a change has a decisive impact on *sales planning (Core task: Production program planning)* since customer requirements are decisive for this planning. From the sales plan, internal production demands, based on end products, can be identified. The characteristic attribute therefore also correlates with the tasks of *product program planning (Network task: Network config.)* and *primary demand planning (Core task: Production program planning)*. If a change is initiated by the customer, his sales orders may be affected, which in return may have an impact on the *order release* task of the in-house production planning and control. Through the correlations between characteristic schema and Aachener-PPS-model tasks, the specific problem was transferred to the solution space according to TRIZ methodology. Based on these correlations, the user can understand how the characterized change request affects certain production tasks. After that, a connection to IT systems must be established to provide the user with additional data and information. This allows effects of the associated change to be evaluated on a data basis. Therefore, the second step of the transformation, the correlations between tasks from the Aachener-PPS-model and IT-modules and functions were analyzed. For this purpose, the current performance range of ERP and MES were analyzed. The range of performance was defined by the means of requirement specification sheet, which are used for the selection of ERP and ME systems. The requirement specification sheets for ERP and MES were provided by Trovarit AG. The Trovarit AG supports national and international companies in the selection of ERP and ME systems. It has a platform on which over 700 ERP providers and over 350 MES providers are listed to participate in tenders. The analyzed requirement specification sheets are used for these tenders.

As a result of the analysis, connections are made between the tasks of the Aachener-PPS-model and modules of the IT-Systems. At this point, correlations are to be clarified based on the task *In-house production planning and control*. This core task of the Aachener-PPS-model is characterized by controlling and planning activities. These includes planning functions such as *detailed resource planning* and *sequencing of production orders*. These planning functions are described in the *production planning* IT-module which is why this IT-module is clearly related to the core task *In-house production planning and control*. Furthermore, a comparison is made with the current stock levels and stock status as part of the material availability check. This clearly shows that *material and warehouse management* as an IT-module is affected to the *In-house production planning and control* core task. As a result of the analysis, correlations to modules of *production planning*, *material master data management*, *material and warehouse management*, as well as *shipping* can be determined. The complete result of the analysis for all tasks of the Aachener-PPS-model is summarized in Figure 4.

Tasks of Aachener PPS-Model	Correlating IT system modules
Core tasks	
Production program planning	Sales, Production planning
Production demand planning	Disposition, Purchasing & Procurement, Material master data management, Production planning
In-house production planning and control	Material master data management, Control level, Shipping, Materials & warehouse management, Production planning
External procurement planning and control	Purchasing & Procurement, Materials & warehouse management
Network tasks	
Network configuration	Production planning, Disposition, Purchasing & Procurement, Sales
Network Sales Planning	Sales
Network Demand Planning	Purchasing & Procurement, Production planning, Disposition
Cross-sectional tasks	
Order management	Sales, Service & Repair, Production planning, Materials & warehouse management
Inventory management	Disposition, Control level, Materials & warehouse management, Material master data management, Production control
Controlling	Control level, Materials & warehouse management, Material master data management, Production control
Data management	Total scope

Figure 4: Assignment of IT-modules to production planning and control tasks

Based on this allocation, the detailing of the identified IT-modules can be carried out for all tasks of the Aachener-PPS-model. For this purpose, the requirements specification sheet of an ERP and an ME system were analyzed in detail for every IT-module [20] [21]. To show the correlations, the core tasks were summarized in rows and the IT-modules with their functions are summarized in columns as shown in Figure 5. In the following, the scope of the core task *Production demand planning* will be explained in excerpts. The aim of *Production demand planning* is the realization of the production program. The determination of demand can be carried out deterministically with the help of bill of materials (BOM) explosion. These are stored in the material master data, which is why there is a correlation to *Material master management* and *BOM management* within the IT function module *Material master data management*. For the *Disposition* module, a correlation to *Material disposition* can be proven since this is decisive for the determination of heuristic requirements. Since no allocation with stocks within the *Gross secondary demand determination* takes place, no correlations can be proven in the module *Purchase and Procurement*. The *Net secondary demand determination* determines the necessary dependent demands to be procured. This takes place by consideration of different stock types, which are planned either on date or summarized within a period. This justifies the correlation to *Production program planning* and *Production planning*. Since material master data are also used, the correlations of the *Gross secondary demand determination* for the individual functions *Material master management* as well as *Material planning* are also valid. In addition, the result is the material quantity to be procured. Therefore, a correlation must exist in the context of *Order quantity determination* and *Purchase requisitions*. The subtask *Procurement type allocation* must determine for the materials to be procured, according to which procurement type is acted. This is stored in the material master data, which is why there is a correlation with the function *Material master management*. The strategic *Make-or-buy decision* is a core component of *Production demand planning*, which is why the associated task correlates. *Lead time scheduling* structures the production process from a time perspective. Compared to detailed *In-house production planning and control*, rough key dates are targeted. For this, an unlimited capacity of resources is assumed. *Resource management* is therefore directly affected. The reference to production orders is established in the context of *Production planning*, which additionally enables the possibility of a first rough *Production simulation*. For the subtask *Capacity demand determination*, the required available capacity is determined. The processing time depends on the unit lead time and the number of units. Therefore, a correlation to *Lot sizing* can be identified. The entirety of the correlations is shown in Figure 5.

from \ to	Functional modules of operational application systems for production																				
	Material master data management				Disposition			Purchasing and Procurement								Production planning					
	Material master management	BOM management	Connection PDM/CAD	Variant Management	Make-or-Buy-Decision	Material disposition	Kanban	Supplier Management	Purchase requisitions	Order quantity determination	Purchase order processing	Purchase order monitoring	External production	Invoice verification	Supplier frame orders	Resource management	Work preparation	Lot sizing	Production program planning	Production planning	Production simulation
Core tasks: Production demand planning																					
Gross Secondary Demand Determ.	●	●				●													●		
Net Secondary Demand Determ.	●					●			●	●									●	●	
Procurement type allocation	●				●			●			●		●							●	
Lead time scheduling																●				●	●
Capacity demand determination																●		●		●	
Capacity coordination																●	●			●	●

Figure 5: Correlation between Production demand planning and IT-Modules

3. Outlook and need for further research

The results of the study are two transformation matrices which enable a transfer to modules and functions of the operational application systems ERP and MES. The approach generates a standardized procedure for transforming and evaluating change requests. Users can link the change request with data and information from operational application systems. The approach presented in this paper enables users to understand the linkage between tasks of the production system and specific IT functions. The first transformation matrix is used to transform an objectively recorded change request. The use of the Aachener-PPS-model guarantees a high degree of transferability to manufacturing companies. The second transformation enables the user to identify affected IT functions. Discussions with providers of ERP systems and experts from industrial practice show that the use of standardized requirement specification sheets enables a high degree of transferability to industrial practice. The approach presented in this paper can therefore be applied regardless of the IT-Systems used. This allows an integration into the change management processes of industrial companies.

Further research must be conducted to define the preparation for decision support. Regarding the usability of the presented approach, special attention must be paid to the management suitability. It is necessary to describe the impact effects of a change request in a standardized way. Only an objective presentation of the evaluation result guarantees the reliability of a following evaluation process. In conclusion, the combination of objective recording, transformation and evaluation allows a comprehensive and objective evaluation of change requests. The approach presented in this paper contributes to the further development of production systems that can adapt more quickly to changing customer requirements.

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Biography

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Prof. Dr.-Ing. Volker Stich (*1954) has been head of the Institute for Industrial Management (FIR) at the RWTH Aachen University since 1997. Prof. Dr.-Ing. Volker Stich worked for 10 years for the St. Gobain-Automotive Group and lead the management of European plant logistics. In addition, he was responsible for the worldwide coordination of future vehicle development projects.