An Innovative Service Business using a Holistic Availability Management System

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Abstract

As a result of constantly growing market requirements and an increasing complexity of machining systems, rising demands emerge on machine productivity, as well as the need for flexibility and availability of production processes. Furthermore, this calls for an innovative and holistic availability management system, which ensures an availability increase by using a significant, process-accompanying and rule-based condition information system. In this information system all condition-relevant data, received from heterogeneous sources, is brought together on a homogeneous platform. Besides, a holistic solution is supported by the cooperation of manufacturers, suppliers and operators which guarantees the consideration of all possible availability losses regardless of their causes. This paper describes the technical challenge and a first holistic approach to develop such a system that ensures an optimized maintenance and production planning based on a reliable and convincing analysis of the actual condition of machines or production systems. With regard to this, chances arise to evolve different business models.

Keywords

Availability Management, Maintenance, Business Model

1 INTRODUCTION

Nowadays, production systems are either extremely versatile or highly productive. But market requirements and industry force a balance of those two divergent demands. Both aspects increase a company's dependence on the availability of their machines and systems, which is directly connected with the functional efficiency of several machine components. The demand to gain high productivity comes along with an increasing complexity of machining systems. In this context the availability of production processes is a crucial factor of success, especially for small- and medium-sized enterprises. [1], [2], [3]

Considering high purchase costs for production systems, a need arises for solutions to reduce downtime and therefore to avoid an economic loss. Furthermore, the impact of a downtime is much higher due to the growing complexity of production systems and also because of the increased coupling of production processes of multiple companies in a supply chain. In addition to that, the risk that seemingly small causes of malfunction are going to cause significant damage is also going up. To ensure the availability and furthermore increase it, there is a need for a significant evaluation - a reliable and convincing analysis - of the current condition of machines or production systems. This analysis coevally forms a basis for the optimisation of the maintenance activities. [1], [3]

The paper motivates and describes the technical challenge to develop a holistic rule-based, process-accompanying availability management system. This management system is not only consisting of condition monitoring tools, but involves also organisational aspects and machine control-data. The main task therefore is to connect both sensor- and machine control-data near real-time on the technical side and organisational data from the production planning. In this information system all condition-relevant data, received from the already mentioned heterogeneous sources, is brought together on a homogeneous platform. For this aim, the holistic solution has to be supported by the cooperation of manufacturers, suppliers (sensor producer, IT-specialist), service providers and operators, which guarantees the consideration of all possible availability losses regardless of their causes. [2], [3]

Following this concept, the holistic availability management builds up an innovative business model as a whole, as well as there are chances arising to evolve different business models for each participating partner in the availability management system. The paper thus also focuses on the systematisation of those availability-enhancing business models, which reveals a great variety of characteristics and technical possibilities to increase the availability. [4]

2 HOLISTIC AVAILABILITY MANAGEMENT SYSTEM

2.1 History of Maintenance

In recent years the basic understanding of maintenance has changed from the focus on the costs caused by maintenance activities to the costs which could be prevented by means of an efficient maintenance [5]. Furthermore, maintenance is no longer only a matter of physical machine care, inspection and repair of machines and systems. Many companies face the task of maintenance as a complex challenge. The central idea is still to maintain a machine's capability. But meanwhile also the elimination of weak spots -in a structured and systematic way-, as well as the continuous improvement of the functional reliability are taking centre stage [6]. Figure 1 shows the history and development of maintenance: starting with a quite trivial reactive maintenance (fire-fighting-strategy) beyond a preventive, acting maintenance, leading to a complex, need-based and condition-based maintenance supported by state-of-the-art technology. It is no longer reacting or preventing but monitoring, acting, adapting and optimising.

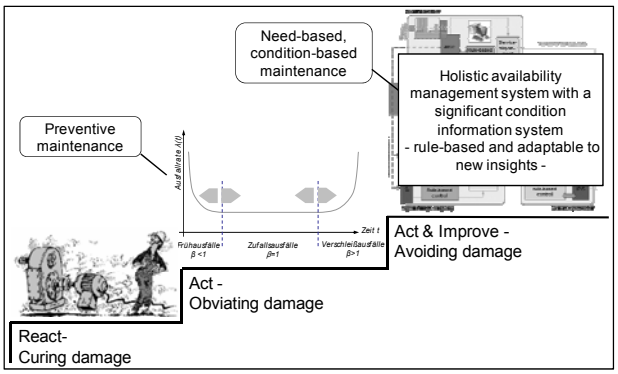

Figure 1: The history of maintenance.

2.2 Structure for an Availability Management System

Depending both on the field of application and the type of production system, there are a several different strategies to maintain a machine or a plant. As mentioned, there are, for example, reactive or preventive, in other words active maintenance strategies more or less using condition-based maintenance activities. Within the joint project VERA^{PRO}, initiated by the German Federal Ministry for Education and Research, a concept that enables a significant and meaningful assessment of the current machine condition and thus enables an optimisation for all the maintenance activities was developed. Thereby, the generation of machine data out of the field, provided by the operating company, builds up the basis for a rule-based condition analysis closely connected with process data. By the use of modern communication channels, there was a scenario developed and implemented where the machine manufacturer is able to analyse data of his already sold machines. In addition to that it is possible - particularly for the manufacturer of machines - to gain an overview across all production systems in order to detect manufacturing faults or breakdown patterns through the coupling of condition data with the data of the machine production process. By doing so, special measures, both to eliminate system defects and to adjust maintenance activities, could be initiated.

As well as there is the scope of action for the machine manufacturer, there arises a field of action for specialised service providers. With the aid of condition-based maintenance strategies the service provider guarantees a defined availability.

The realisation of the holistic availability management system with the involved and mandatory, different parties accounted for a substantial exchange of, at least in most instances, sensitive machine data. Therefore, a secure and anonymous data transfer was fundamental.

Within the availability management system a condition information system - on the basis of condition-based maintenance - was developed, which is able to combine special individual solutions (e.g. condition monitoring systems, remote services or maintenance plans) and consolidate comprehensive planning systems joined on one platform. The continual attainment of new insights about the correlation between condition data of production systems (generated by condition monitoring systems), product-related data (from production planning and control systems, quality systems or similar systems) and economic strategies as well as suitable measures to increase the availability were further aims of the availability management system. Those insights were transformed and transferred into a system of rules, located at the production system. The usage and adaptation of those rules led to continuously improved condition information. In order to implement an ideal management of availability, the cooperation of several interdisciplinary task managers as manufacturer, operator, sensor manufacturer, service provider, communication system manufacturer and maintenance management system manufacturer is necessary, which was supported by the consortium in the joint project (see Figure 2).

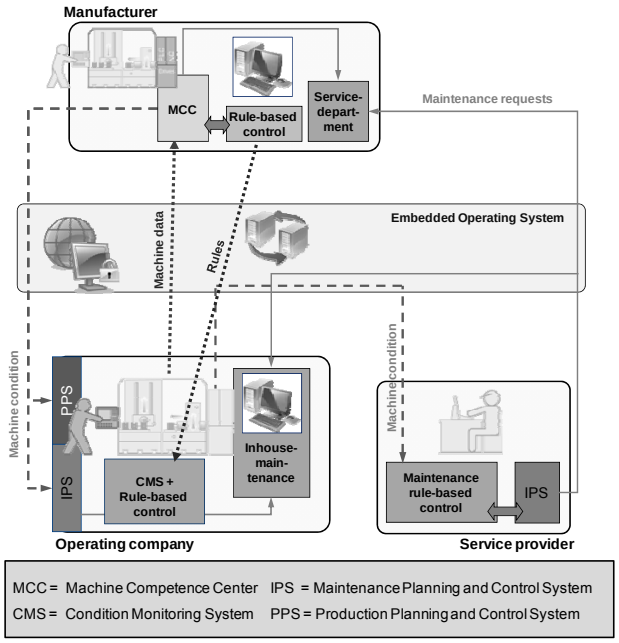

Figure 2: Overall scenario of the availability management system (joint project VERA^{PRO}). [1], [2], [3]

Thus, the individual requirements for an increase of availability could be determined corporately and then be transferred into the management system. Hence, manufacturers of production systems with their knowledge about the technical realization of highly available systems, operators with their specific data about real utilisation, abrasion and attrition ratios have defined the common purpose. [4]

Concerning the implementation of a condition information system and an adjusted maintenance strategy within the holistic availability management system, the financial aspect is very important. For the development of suitable business models, the benefit has to appear to achieve a change in the corporate culture and to guarantee a successful implementation of this concept. [1]

3 BUSINESS MODEL

3.1 Basic business model definition

The bases for entrepreneurial action are business models, which describe the fundamental aspects and architecture of the business of a company. There are several views about the structure of business models, which are reflected in various definitions of business models [7]. The systematisation of the business models, developed in this joint project, was geared to the definition of business models by Stähler [8], which focuses a high costumer orientation and customer value. Following this definition, a business model is divided into three stages: the customer value, the architecture of value creation and the turn over model (see Figure 3).

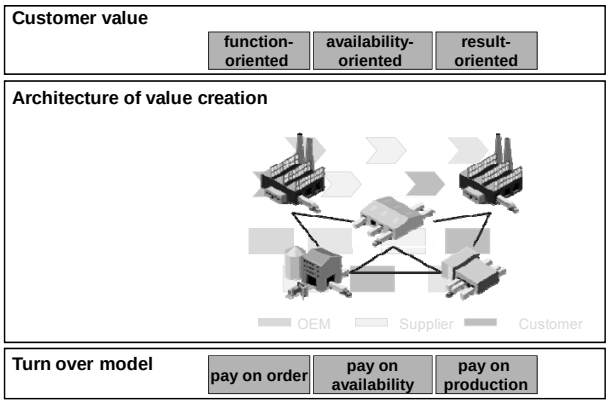

Figure 3: The architecture of business models by Stähler [8].

Based on this structure, relevant aspects are the stakeholders, the attainments and the configuration of trade-off. The customer value describes the benefit which customer or another value adding partner could reach from dealing with the company; it answers the question: which benefit does the company endow? A concept of business is an architecture of value creation at the same time by describing how the benefit for the customers is generated. This architecture gives a description of the different stages of value creation and economic agents with their special roles within the added value. It answers the question: in which configuration and how is the attainment being created? The turn over model gives an idea about which revenues the company is achieving from which sources. Then the future revenues will determine the benefit of the business model for the company. Furthermore, it could also draw a conclusion about the sustainability of the business model. In summary the turn over model answers the question: How does the company earn money?

Based on dynamic systems, the customer value could be differentiated between function-, availability- and result-orientated business models. [9] A function-oriented business model comprises, for example, a maintenance contract in order to guarantee the functionality for an assured period of time. In an availability-oriented business model, the usability of the means of production is also guaranteed. The supplier takes over business processes of the customer as his own responsibility, e.g. maintenance or repair and thus bears a part of the production risk. In a result-oriented business model, the complete responsibility of the production result is transferred to the supplier. The customer pays only for the faultlessly produced parts.

3.2 Conclusion

There is an explicitly formulated or at least an implicitly existing business model behind every valuable consideration. Accordingly, a company, which offers different services and products - thus various conditions for the customer, could be represented by different business models. Due to the various specifications of service offers, a detailed description of a business model is very considerably. Against the background of availability increasing business models, these assumptions are also valid for the mentioned availability-oriented business models and especially for the services within an availability management. This fact reflects the idea of an Industrial Product-Service System (IPS²). IPS² represent a paradigm shift in the definition of service performance in mechanical engineering by considering tangible and intangible goods in an integrated way [9]. The concept of IPS² considers the integration of products and services to enable new business models aiming to fulfill customer needs [10], [11].

4 BUSINESS MODELS WITHIN THE JOINT PROJECT

The business models developed in the joint project VERA^{PRO} contrast with other business models by having the benefit for the operator of production systems (the customer) by increasing the availability.

While dealing with a systematisation of availability-increasing business models, there arised a large variety of characteristics and technical possibilities to enhance and ensure the availability of production systems (see Figure 4). In consideration of the holistic availability management, three dimensions of action could be identified in the project. These are an operational-reactive, an operational-constitutive and a strategic dimension. The dimensions mainly differ in the space of time, which is given to execute the availability increasing measures and the therein included measures for realisation. Within the three dimensions, there are a variety of functions and actions, which are different, depending on the business model characteristics (e.g. organisational availability increase, technical availability increase, ...).

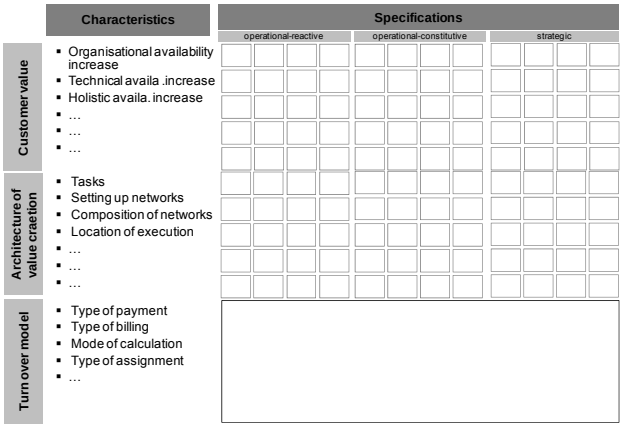

Figure 4: Structure of availability-oriented business models. [4]

In order to assign the actions to the characteristics and specifications and to structure them, there is a need for a systematic combination of the components of the business model.

An approach, which can solve this task, is the method of Quality Function Deployment (QFD). Other approaches like scoring models are too vague.

5 SYSTEMATISATION OF BUSINESS MODELS

5.1 Quality Function Deployment and house of quality

For business operations the customer orientation is an important element. In this context, the Quality Function Deployment is able to support a customer-orientated product- and process development. The QFD model consists of four phases, respectively four houses of quality (HOQ) [12]. The customer demands will be transferred into product characteristics and processes as well as into the production planning. The house of quality consists of a matrix which evaluates the correlations between demands and solution characteristics. Furthermore, an interdependency analysis builds up the roof of the house of quality. Customer requirements could be surveyed by market research, then be analysed and transferred into QFD-suitable information. In the first HOQ the production

is planned by translating the customer requirements into quality characteristics. In the second HOQ the planning of the several components is focussed by assessing the relevance of each component concerning quality characteristics. The aim of the third HOQ is finally the process planning. Based on the necessary production processes and characteristics the manufacturing specifications are generated. By transferring the manufacturing specifications into production instructions the production planning is developed in the fourth HOQ.

5.2 QFD for business model development

Following the conclusion by analogy the development of business model could be based on the QFD. Therefore, QFD concretises the configuration of product-service systems and processes within the business model. Thereby the proceeding follows the development mentioned above. First of all, the customer demands were opposed to the characteristics of product-service systems for a holistic availability management. The assessment of the correlation of customer demand and the characteristics of product-service systems in the availability management is done by experts. In the next step, the characteristics of product-service systems were broken down into functions within a matrix. By doing so, it is then possible to judge which processes are necessary. The last matrix for the characteristics of product-service systems checks the requirements, e.g. the equipment characteristics for the processes. An overview of the development is given in Figure 5.

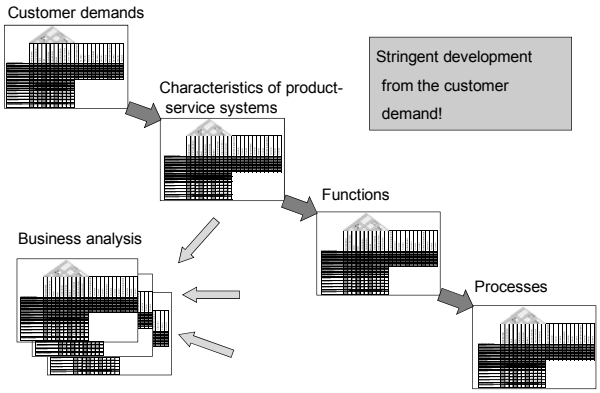

Figure 5: Customer-oriented availability-based business models.

6 SUMMARY

To establish a holistic availability management system, there is a need for a special structure or scenario based on a comprehensive information system. In this information system all condition-relevant data, received from heterogeneous sources, is brought together on a homogeneous platform. Therefore, it has to be supported by the cooperation of manufacturers, suppliers and operators, which guarantees the consideration of all possible availability losses regardless of their causes to accomplish a holistic solution.

According to the participation of the several partners, an innovative business model could be built. Furthermore, there are chances arising to evolve different business models for each participating partner in the availability management system. Based on this, there emerges a need to systematise those availability-enhancing business models, which reveals a great variety of characteristics and technical possibilities to increase the availability.

The QFD could be used for the configuration of the business model as well as for a customer-specific configuration of product-service systems. Within the business model definition by Stähler the QFD could make a considerable contribution to the structuring of marketing activity. The most striking advantage of QFD is the stringent focus of the development of business models on customer demands. The introduced approach is implementing by the project partners of the joint project VERA^{PRO} and his evaluation will generate new consolidated findings.

7 ACKNOWLEDGMENTS

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