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Process Performance Measurement as Part of Business Process Management in Manufacturing Area

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1. Introduction

Process performance measurement tools and techniques applied to enterprise environments are essential for enterprise continuous improvement. It is the reason why the next generation of process management leads to Process Performance Management or Corporate Performance Management. The phrase Corporate Performance Management (CPM) was coined by Gartner Group to describe the combination of process, methodologies, metrics and technologies to measure, monitor and manage the performance of the business. The oft-cited phrase: “*If I can not measure it, I cannot manage it*” can be motivation of this chapter.

This chapter deals with presentation way leads to establishment of efficiency system for process measurement and controlling in the manufacturing area. The process measurement can be defined as the application of the management cycle with a focus on organizational process. Muehlen present process management as the collection of planning, organizing and controlling activities for the goal-oriented management of the organization’s value chain regarding the factors quality, time, cost and customer satisfaction (Muehlen, 2004). The main goals of process management are the achievement of transparency with regard to process structure and process contribution.

The description and practical application of process performance management system will be presented in case study. The case study also presents exploitation of data from an enterprises information system for decision-making is next point of this chapter.

2. Related work and literature review

The process controlling has been discussed in the published books and papers in scientific journal (Shen, 2007) and (Aalst, 2007). A. Kronz presents principal tasks of process controlling in book (Scheer, 2006). He mentioned these points:

1. Evaluation, analysis and continues monitoring of business workflows (automatically or manually),
2. Map the process reality in a task-oriented manner according to the issue and task.
3. Result of process controlling is transparency of the process, in structural terms and for purpose of evaluation,

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4. Results can also be used as the basepoint for process optimization.

Next author Michael zur Muehlen discusses in his book (Muhlen, 2004) of the workflow audit trail data with existing data warehouse structures and develops a reference architecture for process-oriented information system.

The term of process controlling has been often discussed in relation to process management, because implementation of business process management is a way how to achieve of process performance management system establishment. The "Process Management and "Business Process" are contemporary terms used in the many companies. Many successful companies applied this management approach based on Hammer's Business Process Reengineering Concept (Hammer, 1993). The authors develop the Hammer's and Champy ideas in related works nowadays.

Many articles in journals and international conferences proceedings deal with BPM issue. High number of citations on business process management (BPM) seems to prove that BPM is a significant field of the recent research (Harmon, 2008). For example a Google.com search on „Business Process Management“ returns more than fourteen thousand pages where this phrase appears. The BPM issue is the subject of research focused on methodological or technological solution of BPM problems (Weske, 2007). The main problems are described by Wasana Bandara in article (Bandara, 2007), where fourteen global experts were interviewed for example. The problems examples show the lack of governance, lack of standards, lack of methodology, lack of tool support for process visualisation etc.

The main principles of process measurement system are described by the authors and many authors discuss about phrase Corporate Performance Management. The phrase Corporate Performance Management (CPM) was coined by Gartner Group to describe the combination of process, methodologies, metrics and technologies to measure, monitor and manage the performance of the business. Prof A. W. Scheer discusses this issue and trends of CPM in his book (Scheer, 2006).

CPM is thus directed at continues monitoring of the effectiveness of the results of all company processes and the constant optimization thereof, i.e. its objective is a monitoring system that monitors the business performance of all pertinent business processes all the time, detects and reports weaknesses and problem situations, ideally even suggests optimization option and evaluates the success of improvement measures. Substantive recommendations for actions, including their chances of success, are needed so that the better decisions can be made more quickly. Process Performance Management may be regarded as the heart of CPM. (Scheer, 2006)

The present trends in Corporate Performance Management are:

- Process mining for automated weak point analysis
- Right time monitoring
- Dynamic organizational analysis

These trends describe the purpose of application of process controlling in the manufacturing area. The application of process controlling based on process management principles for technological and diagnostics process control is one objective of our research. The main objectives of our research are design and verification of a control system based on business process management approach for control of process in the diagnostics and the electrical engineering and electronics manufacturing. In the following case study, I shall describe the practical demonstration of process controlling application.

3. Research methodology and methodology framework

3.1 Design of generic methodology

Designed methodology concept helps to implement the process performance measurement system based on process controlling. The concept has been developed into two steps:

1. Analysis of processes and current needs of responsible managers, staffs, researchers and technicians. The designed questionnaires can be used in this step. We have obtained process attributes of key processes.
2. Study, selection and modification of suitable methods and tools for business process management and performance measurement.

The application of designed methodology is demonstrated on case study. Data collection for this case study was conducted these different techniques:

1. Questionnaire – This method was used for process analyses and mapping of process attributes. The main problems were done via structured question to management and workers.
2. Participation/Observation – The researches were able to observe and processes in operation and validate recorded data.
3. Interview – This method enabled the collection information of management vision and requirements.

3.2 Generic methodology framework

Methodology framework is presented by Table 1. As we can see the table presents key steps and activities in defined order. The methodology concept is based on business process and process performance management theory. It means application of Business Process

Step	Activities	Output
Business strategy definition	Analysis of current situation Definition of mission, vision and strategic goals.	Strategy are defined
Process design	Implementation of process modeling methodology Process models making Definition of main optimization criteria Process optimization	Processes are designated.
Process Controlling Implementation and Indicators Setup	Design of process measurement and execution system Determination of periodicity of process measurement Implementation of tools for process measurement, execution and evaluation Design of system for correction proposal and improvement	System for process evaluation and execution of processes is implemented. Improvement system is defined.

Table 1. Designed methodology framework

Management in first step. This step leads to:

- process analysis and key process indicators setup
- process description, modeling and optimization,
- system of evaluation and process execution.

The information infrastructure can be applied for the methodology support. The information structure should be built on Service Oriented Architecture (SOA) which provides methods for systems development and integration where systems group functionality around business processes and package these as interoperable services. SOA also describes IT infrastructure which allows different applications to exchange data with one another as they participate in business processes. Service-orientation aims at a loose coupling of services with operating systems, programming languages and other technologies which underlie applications.

3.3 Methods for process performance management

The current management literature presents different methods for process performance management. Firstly, they are methods based on financial analysis of basic enterprise economic indicators (for example Economic Added Value measurement, DuPont analysis). Secondly, they are management methods used the financial and non financial indicators (typically represented by Balanced Scorecard method (BSC), EFQM model, Six Sigma, Value Based Management). The Balanced Scorecard method sophisticated presents how to define and implement the key process indicators and metrics for performance evaluation. Many companies have adopted Balanced Scorecard as a way of evaluating managerial performance.

This methods supplements traditional financial measures with three additional perspectives: the customers, the internal business process and the learning and growth perspective. It is supposed to be a tool describing an organization's overall performance across a number of measures on a regular basis.

The basic idea is very straight forward. Kaplan and Norton began by arguing that "What you measure is what you get" and that "an organization's measurement system strongly affects the behaviour of managers and employees." They went on to say that "traditional financial accounting measures, like return-on-investment and earning-per-share, can give misleading signals for continuous improvement and innovation..." To counter the tendency to rely too heavily on financial accounting measures, Kaplan and Norton argued that senior executives should establish a scorecard that takes multiple measures into account. They proposed a Balanced Scorecard that considered four types of measures:

1. Financial Measures: How Do We Look to Shareholders?
2. Internal Business Measures: What Must We Excel At?
3. Innovation and Learning Measures: Can We Continue to Improve and Create Value?
4. Customer Measures: How Do Customers See Us?

The BSC method gives a definition of strategy as hypothesis summary about causes and results. It can be declared as a sequence of "if – then". The BSC, proposed by Kaplan and Norton, is the strategic management instrument:

- to clarify and translate vision and strategy,
- to communicate and link strategic objectives and measures,
- to plan, set goals and align strategic initiatives,
- to enhance strategic feedback and learning.

4. Case study

The case study is focused on printed circuit board production. This production is one part of our department and its customers are other universities departments and small companies from the Pilsen region. The objective was to establish the performance measurement system focused on process time measurement and real processes current status analysis. This case study also presents application of designed methodology.

4.1 Business strategy definition

Definition of core problem and strategy of company was first task. The core problem of visualization was effectively solved by the Current Reality Tree (CRT). This chart shows causality of relevant undesirable effects of the analyzed situation. The practical example is shown in Fig. 1. The main problem is fall of profit related to production time, capacity and quality of process. On the other hand this situation might be described by a conflict diagram (Fig. 2). The diagram describes decision and optimizing problem of manufacturing - determination of optimum batch size.

The conflict exists between increasing and decreasing of the batch size. The increasing of production run (D) makes to cost reduction (B) and decreasing (D) of the batch size makes to high quality of products (C). Both described situations have negative effect on the

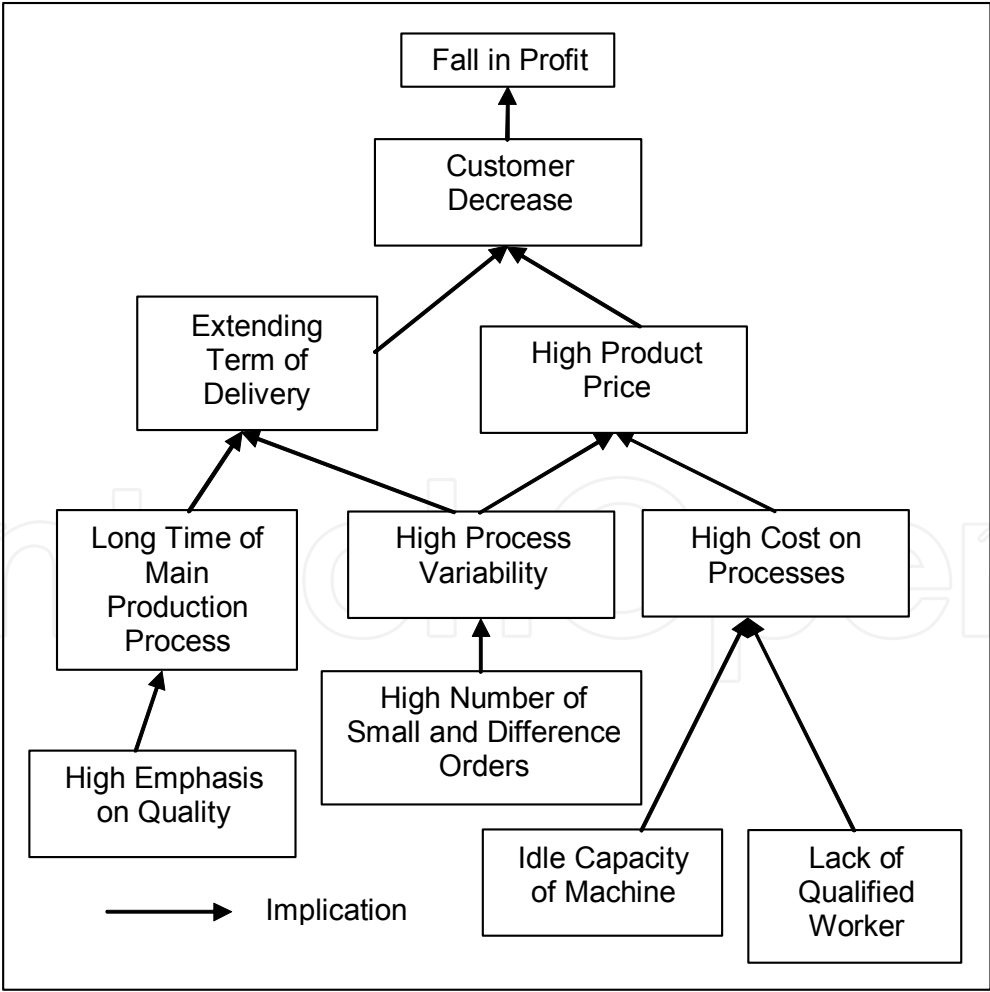


Fig. 1. Current problem of causality

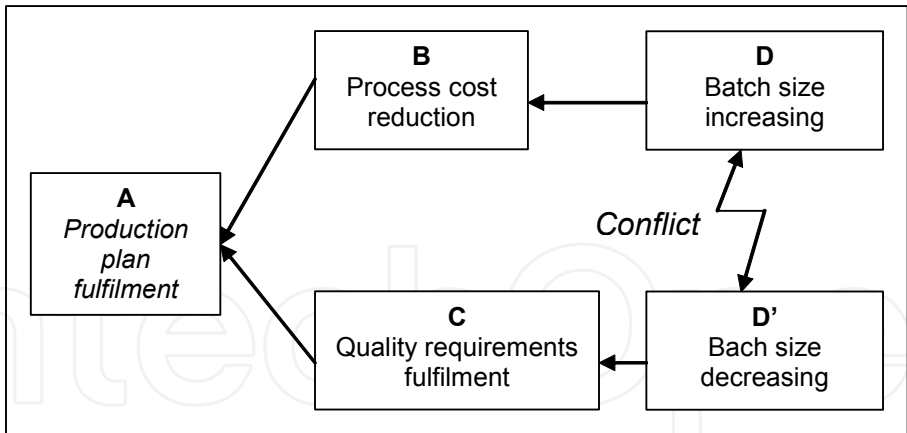


Fig. 2. Conflict diagram of company

production plan and profit. These problems and conflict were solved by designing methodology effectively. So cost reduction, quality improvement and time reduction were the main optimizing criteria according to methodology. Secondly, the business strategy and main key process indicators were developed according to Balanced Scorecard. The Table 2 shows process indicators and the strategy is describes in ARIS model (Fig. 3). From this model we can make performance dynamic execution (it is part of last step methodology implementation).

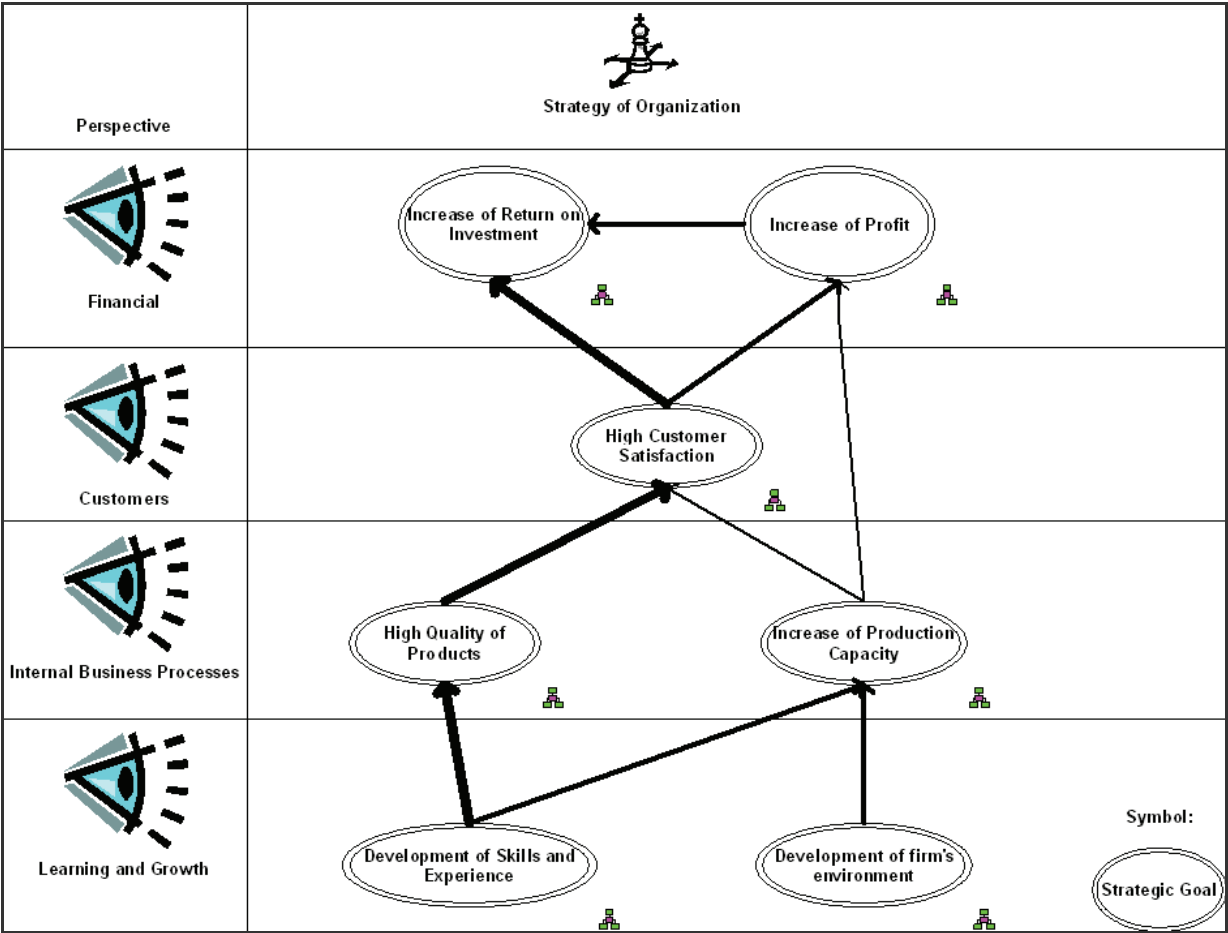


Fig. 3. ARIS model of Balanced Scorecard business strategy

Process indicators	Staffs Satisfaction	Internal Productivity	Customer Satisfaction	Training Course	Fail-ures	ROI	Process Time	Process Costs
Unit	[%]	[-]	[%]	[number]	[number]	[-]	[min]	[EUR]
Minimal Value	75	2	80	1	95	4	24	40
Maximal Value	100	4	100	3	100	8	72	60
Tolerance	5	5	5	5	5	5	5	5
Period	Q	Q	Q	Q	Q	Q	Q	Q
Planned Value	95	3	90	2	99	5	48	50
Current Value	95	1,5	85	2	98	5,3	75	75

Table 2. Strategic indicators

4.2 Process design

The process analysis and process modelling was the first important steps lead to process design. It contained following activities:

- definition of the process model and attributes. It means determination of targets, key processes fragments, key performance indicators (KPI) and their dimensions,
- processes fragment modelling (Fig. 5).

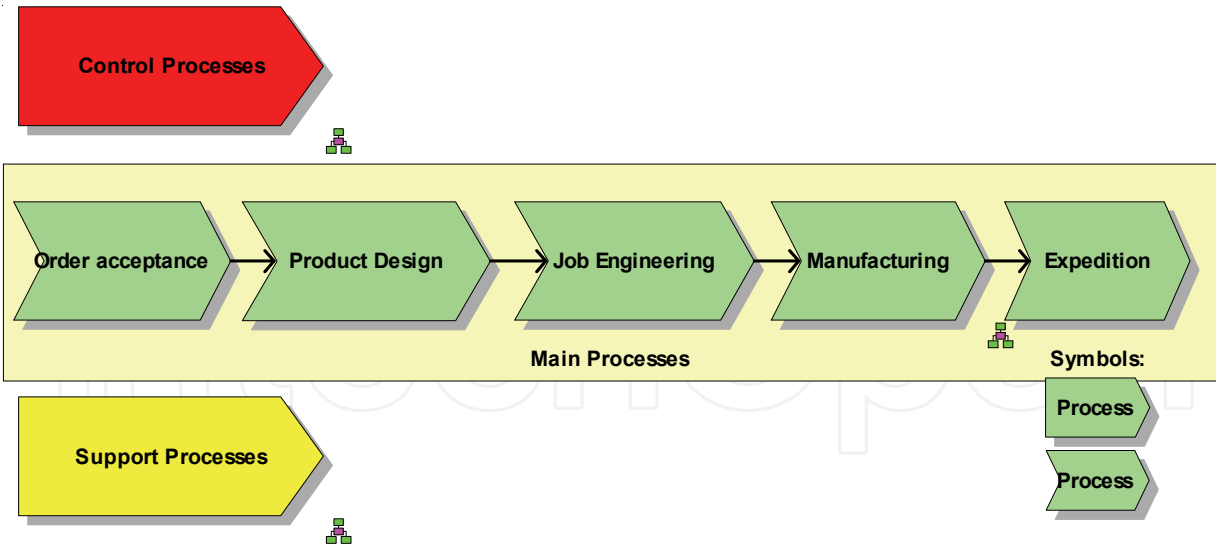


Fig. 4. Core process model of PCB production

The ARIS (Architecture of Integrated Information System) tools and process analyses were used in this part. The main problem was fall of profit related to production time, capacity and quality of the process. Due to this fact, the process controlling application based on CPM leads to this core problem minimization.

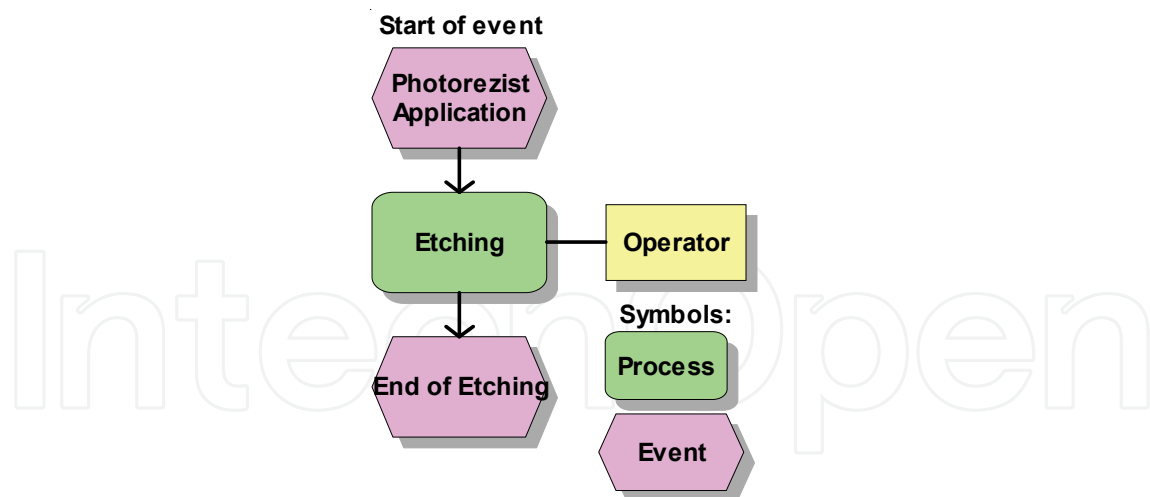


Fig. 5. Model of process fragment

4.3 Process controlling implementation and indicators setup

We decided use the ARIS Process Performance Manager (ARIS PPM) software tool for process controlling in this case, because this tool can be implemented to any information system and structure. The information technologies make the important support for business process management nowadays. Owing to the fact that we are using tools ARIS for process modeling and optimization of processes, we decided to use the software ARIS PPM. With ARIS Process Performance Manager, IDS Scheer company offers a software solution that is a purpose-built for controlling and analyzing business processes. As a part of this solution, a patented procedure is used to collect process relevant data from the operational IT systems available for reconstructs process automatically and calculates key performance indicators online and particularly for presenting the actual process measurement in the form of event-driven process chains (eEPC).

ARIS PPM imports all business transactions to be reviewed into the repository from one or more source systems via application-specific adapters. To begin with, depending on the source system, the process-relevant runtime information about the activities performed is highly disparate in nature (e.g. log files, vouchers, records). These are imported one after the other in chronological order by ARIS PPM and compiled into a process. A graphical illustration – the “event-driven process chain” (EPC) - containing all the individual activities (functions) are then generated automatically for each operation (process instance) – see Figure 8. As a result, even a process that extends beyond the boundaries of a single system can be represented cohesively and uniformly.

The ARIS Process Performance Manager tool has these important functions for Process Performance Management:

- Visualizing Real Process Structure
- Key Performance Indicators and Analyses
- Process documents
- Weak Point Analysis
- Process Mining: Automated Weak Point Analysis
- Management Views
- Offline Reports

Key process indicator	Type	Category	Description
Interval of order processing	Process	Time	Process duration from an order acceptance till issue of an invoice.
Interval of acceptance of an order	Process	Time	Sub process duration: "Receipt of order".
Interval of PCB design	Process	Time	Sub process duration: "Design of PCB".
Interval of manufacturing preparation	Process	Time	Sub process duration: "Manufacturing data preparation".
Interval of PCB manufacturing	Process	Time	Sub process duration "Manufacturing of PCB.
Interval of PCB expedition	Process	Time	Sub process duration: "PCB expedition".
Interval of invoice issue	Process	Time	Sub process duration: "Issue invoice".
Activity process time	Function	Time	Difference between the end of current activity (process) and the end of previous activity.
Processing time of an activity	Function	Time	Difference between the end of activity and the start of a particular activity.
Idle time of activity	Function	Time	Difference between the start of an activity and the end of previous activity.
Keeping the order term	Function	Time	Difference between planned and real order completion date.

Table 3. Key process indicators definitions

The basis for all processes controlling is a process-oriented key performance indicator system that links the process perspective to the essential controlling aspects for business. The key performance indicators must enable conclusions to be drawn regarding the effectiveness of the processes (e.g. customer satisfaction) and their efficiency (e.g. processing time, delivery reliability, process quality and costs). In addition, the process-oriented key performance indicator system is configured so that it would be possible to make statements about the actual course of the process.

Pre-configured process key performance indicators are calculated and aggregated for each imported process stage. The ARIS PPM base system already includes a core set of key performance indicators, and these are set as default ones regardless to a connected source system. The key performance indicator types can be divided into 3 groups:

- time-related key performance indicators (e.g. throughput times, processing times, frequencies),
- cost-related key performance indicators (e.g. process costs/rates on the basis of the performance standard) and
- quality-related key performance indicators (e.g. number of processors, error rates, deadline reliability)

The process owner can use ARIS PPM to achieve the optimum balance in the "Time-Quality-Cost" magic triangle by taking a number of key performance indicators from each of the three ranges with added weighting and thus to yield a new key performance indicator. These user-defined key performance indicators can be set in the front-end at any time during runtime. Besides the preset key performance indicators, other specific key performance indicators are configured in the ARIS PPM base system as a part of the adaptation to the customer individual environment.

These are defined, for instance, by the process types to be reviewed. The key performance indicators in ARIS PPM are endowed with process-relevant decision variables - "dimensions". These dimensions are also imported from the source systems as features of the individual process instances. The user evaluates the efficiency of his business processes with reference to the interplay between key performance indicators and dimensions in the process analysis.

The set of key performance indicators must be calculated and defined flexibly, and in such a way that it can be expanded to the need of changing requirements of the company specific processes. Besides calculating key performance indicators, it is also necessary to be able to visualize the structure of actual processes since, it is the only way to how obtain generalized explanations for their performance behaviour.

The implementation of ARIS PPM tool has been formulated in project. The project main phases were:

1. Implementation for printed circuit board manufacturing.
2. Verification and validation of results from implementation for PCB manufacturing.
3. Implementation for diagnostic process control.
4. Verification results and examination implementation proposal.

The first two phases were realized in following steps:

1. Conceptual and technical workshop
2. Determination of process instance, fragments, KPI and process attributes. The results of process mapping and analysis from previous part were used in this step. The Table 3 presents used KPI.

The SW tool implementation means installation, customizing and connectivity settings. The manufacture section does not use information system now and data must be recorded on operation record cards. Due to this fact, we had to prepare the special software for CSV files generation and rewrite the data into SW ARIS PPM database using PC. Validation of results and their definition is last step of implementation.

4.4 Result of process controlling implementation

First experience of PPM implementation, based on CPM idea, has shown benefits of this solution in the manufacturing area for technological process control, in this case for printed

circuit board manufacturing. The SW tool ARIS PPM helps us to make analysis and processes monitoring, particularly:

- real process course,
- processes time,
- comparing of the real and planned key indicators value,
- type and kind of order.

The results of process mining and analysis have been used for process models correction and KPI planning. In short, the responsible management obtains quick management and performance view (see Fig. 7, 8).

The solution mentioned above doesn't use sophisticated information system. In this phase the data about process has been collected in excel files. The records from the paper sheet in manufacture section had to be rewritten to ARIS PPM database. In consequence of this we had to realize software for data converting from excel database to ARIS PPM database (CSV data format was used for this converting operation). It is obvious that this way isn't suitable for big data volume. From this reason, the suitable information system has to be implemented in the next project phase. The structure and components of used information system presents Fig. 9.

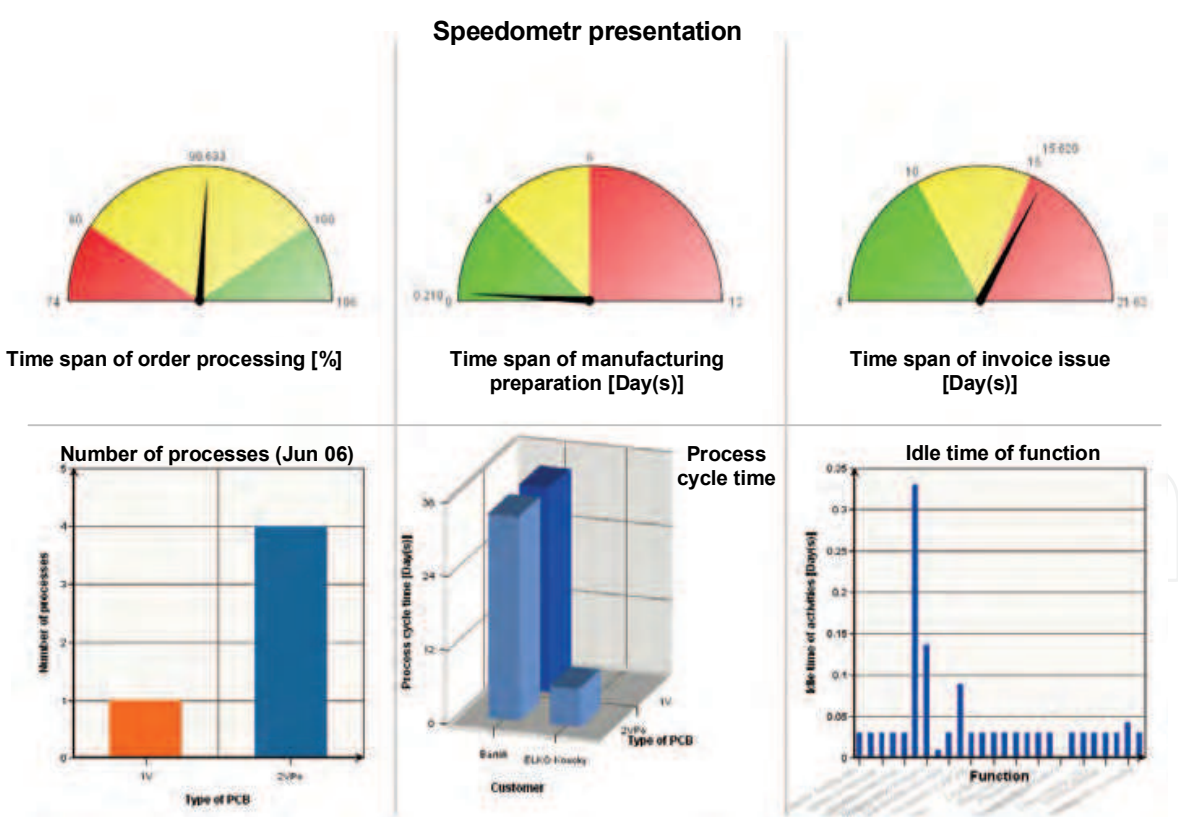


Fig. 7. Management view

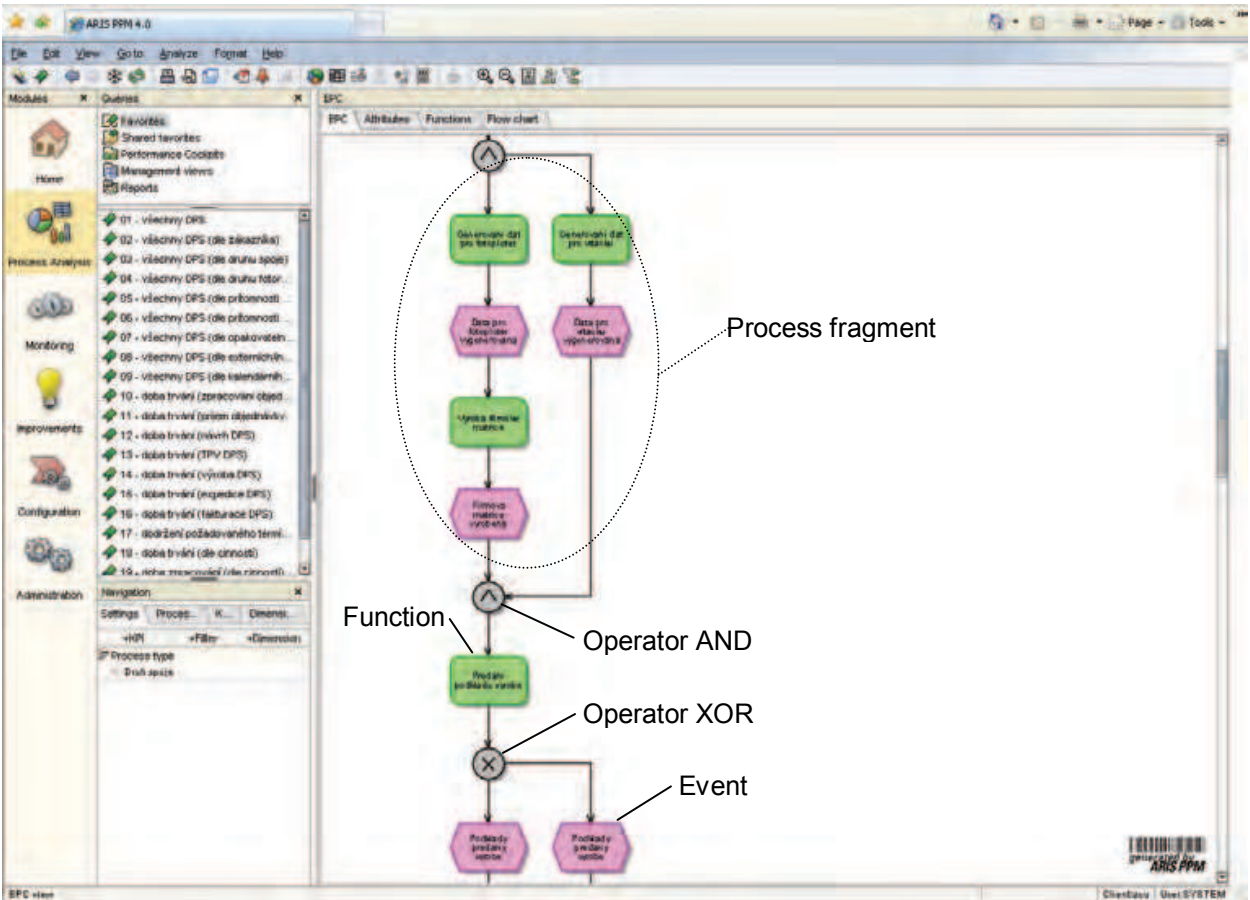


Fig. 8. Visualization of a process instance generated in ARIS PPM

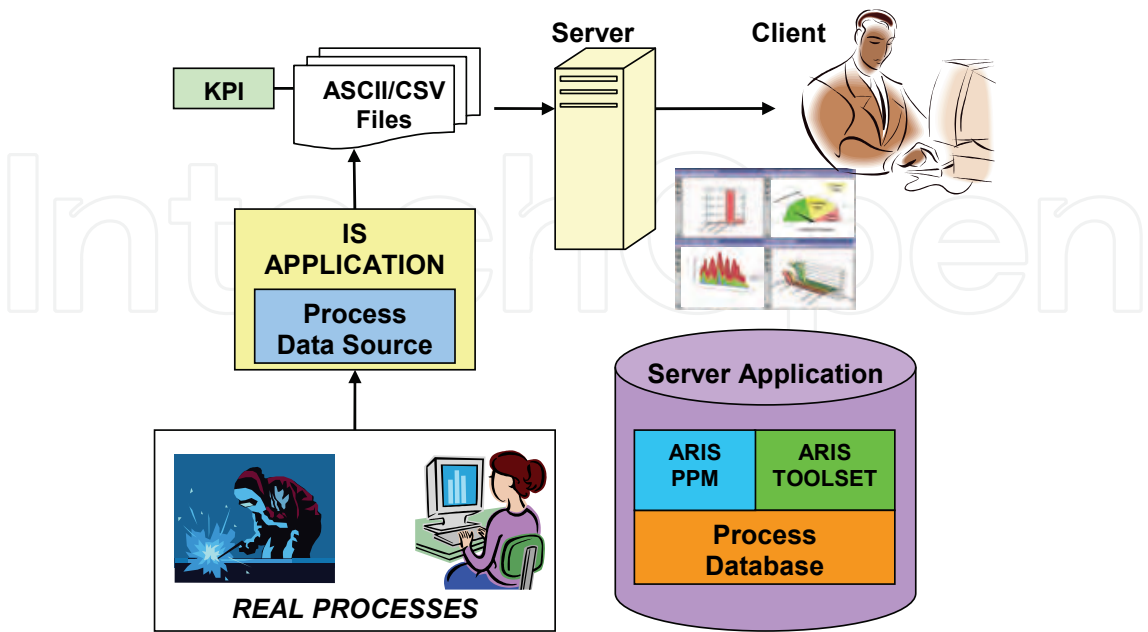


Fig. 9. Information system structure

5. Conclusion

This chapter presents an example of process controlling application. Process controlling described in this paper, comprises the following components:

- Evaluation of the efficiency of business processes based on key performance indicators
- Transparent representation of procedures actually performed for cause analysis.
- Deduction of optimization measures.
- Continuous monitoring of success developments.
- Organizational analysis.

The process controlling is very important tool for process improvement in manufacturing area. The real application in manufacturing area was described in the practical case study focus on the small printed circuit board production. The case study describes way how to analyze the processes and introduces software tools, which have been applied. The benefits and results are documented in the Figures 7-8 as well.

This solution corresponds with the new trend in process management area. Companies that are able to align their business processes to the requirements of their environment and surroundings will not only gain a competitive advantage, but they will also be able to manipulate this alignment better and faster than their competitors. The prerequisites for this solution are the supply of decision-relevant information and an ability to transform this information quickly and effectively into sustained measures for targeted alignment of business processes.

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