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Efficiency of applying a model for measuring key performance indicators in an industrial enterprise

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The paper presents the results of applying the developed models for measuring process key performance indicators (KPIs) in a complex industrial company, including analysis of the effectiveness of its implementation in the analyzed field. The aim of this study was to demonstrate that the general approach and principles of organization and management of an industrial enterprise - based on the integration of its functions are universally valid and that it is possible to establish a standardized system of criteria - parameters (performances) of the process, which in required and sufficient measure reflect the effectiveness of the overall success of the industrial enterprise. On this basis a model of measuring KPIs in the industrial enterprises is developed or the system of parameters of process quality in industrial enterprises which have obtained the conditions for the development of management models for their supervision (monitoring) by the management. Research results indicate that the application of a particular model for the measurement of KPIs in the industrial enterprise led to a higher level of effectiveness of the industrial enterprise as a whole.

Key words: Industrial company, process improvement, key performance indicators (KPIs).

INTRODUCTION

In conditions of rapid change in the market the company can survive and achieve its long-term goals only by timely definition of good strategy and its successful application. In these circumstances the company may have great help in knowing and applying certain methods of management that are used for measuring business results.

Industrial company that nowadays wants to succeed in a turbulent and complex business environment has to adopt such a business policy that will create an organization capable of simultaneously doing three important things - to improve, to expand and innovate (Drucker, 2005).

Industrial enterprises must, above all, consistently apply process approach (ISO 9001:2008) in order to achieve significant improvements. Process approach allows a perception of buyers' demands, and the responses to these requests seek ways how to reach the planned results of management.

Process improvements are a regular topic of different management "debates". Although the majority of industrial enterprises established a system of quality management and thereby committed themselves to application of improving tools, the practice of starting and managing projects of improving is still accessed in an unsystematic way.

Most contemporary studies related to engineering management are focused on the implementation of

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existing and developing new models that will achieve business excellence. Control of the strategic goals is done through inter-organizational measurements and their comparison with historical data from the company database (List et al., 2005).

According to this, the present-day researches deal with the problems of establishing a program of measuring processes in the company. This refers to the process of establishing a measurement process, establishing a database, selecting the appropriate optimal cluster of indicators, extracting the data on measuring sizes, and application of various statistical models of data analysis for improving performance.

Previous research related to recent performance measurement models is based on partial performance measurement whose concept did not give a good insight into the basic factors of achieved business results, not even understanding which aspects of the business should be improved and how to impact on key performance of the company in the future.

Various researchers have been trying to determine a set of quantitative measures to be used for advanced control of software product development processes that involves initiating and controlling the implementation of improvement programs. Thus, for example Wang et al. (2006) proposed an optimal set of measures developed by the case studies from industry.

Abran et al. (2004) gives an example of the functioning of modern methods for measuring the impact of industrial companies with suggestion for efficient and effective process management and quality, in order to achieve business excellence. Management based on quantitative data is one of the conditions for a higher level of maturity in the organization, so the aforementioned model of quality management based on the *International Standards Organization* (ISO) emphasizes the importance of measurement and quantitative process control in industrial enterprises. One of the evidences of the importance of quantitative measurements, such as developing software applications, is the fact that the *Software Engineering Body of Knowledge, SWEBOK* (a standard reference for software engineering), plans to introduce a special area of knowledge devoted exclusively to measurements.

Continuous supervision over the execution of the set of plans is a prerequisite for supervisor's influence on processes control and the elements on which depend their implementation, as well as the responsibility due to their defaults. It is especially important to emphasize that the aim is setting up the planned sizes in variations, so that the participants in the planning process have the choice of those variants that they find as the most acceptable (Schmitz and Platts, 2004; Lin and Yahalom, 2009; Rodriguez et al., 2009).

Generating, processing, and analyzing business data in industrial enterprises is realized with the aim to provide a basis for management decision-making at all levels of management.

Improvement can be successful when based on facts derived from the analysis of the causes of unsatisfactory conditions. This includes different measurements in processes. Improvement of any process cannot be achieved without constant measurement of the process results. It is important to measure the current process results, set goals so as to be measurable, test improvements, standardize the upgraded processes, measure the results of the new process and set new goals. Measuring encourages continuous improvement and continuous improvement encourages and motivates employees. In these processes the application of statistical methods and tools in the process of planning, collecting and analyzing masuring data has no alternative.

In order to develop a model of key performance of complex industrial enterprise, it is necessary to make a connection between the Balanced Scorecard - BSC concept (Kaplan and Norton, 1999, 2001), then the process model of performance measurement (ISO 9001: 2008) and key performance indicators – KPIs.

Model for the measurement of key performance indicators in industrial enterprise was developed as part of establishing quality management system (Đurić et al., 2010).

Garengo (2009) aims to contribute to understanding of performance measurement systems (PMSs) in small and medium enterprises. The paper proposes a framework to classify PMSs and shows how it can be used to study the PMSs adopted by a group of leading Italian SMEs.

Skibniewski and Ghosh (2009) addresses a key question related to enterprise resource planning (ERP) systems applications in the engineering construction industry - what are the areas of business processes within the engineering construction industry where ERP cannot be used to collect key performance indicators related to business processes. The paper Gongbo et al. (2011) aims to identify the KPIs for measuring the performance of value management studies in construction. Likewise, Radujkovic et al., (2010) elaborated role and types of key performance indicators in the construction industry and shown how different management perspectives perceive the indicators.

The basic starting point in developing a model for measuring key performance indicators of industrial enterprises was the criteria of performance, in accordance with the concept of Balanced Scorecard (Kaplan and Norton, 1999, 2001), which are derived from the vision and strategy of the company, which is essentially a balanced model of enterprise management and target performance and their criteria, and which is again based on the financial and nonfinancial "perspectives".

The second segment of the model is a "process model" according to ISO 9001:2008, which requires measurement of performances from specific angles.

Table 1. Processes in a given complex company.

- Process of planning and analysis (110)
- Process of human resource management (120)
- Process of business legal regulation (130)
- Process of quality management (200)
- Process of marketing (310)
- Process of sales (320)
- Process of supply (330)
- Process of finance and accounting (340)
- Process of product and service development (410)
- Process of applying IT (420)
- Process of production of bauxite (510)
- Process of production of non-metals (520)
- Process of production of construction materials (530)
- Process of machine production (540)
- Process of processing of agricultural products (550)
- Process of freight traffic (610)
- Process of long-distance traffic (620)
- Process of passenger traffic (630)
- Process of construction services (640)
- Process of catering services (650)
- Process of storing (710)
- Process of maintenance (720)
- Process of managing measuring equipment (730)
- Process of employees safety (740)
- Process of securing buildings and property (750)

The third segment of the model is establishing a system of key performance indicators that represents the quantitative and qualitative indicators, and is used for measuring, monitoring and managing business results of enterprises and providing the comprehensiveness of the management process. The indicators enable comparison of actual performance size to target sizes of the previous measurement period, i.e. established standards, and the performance of competing companies.

In the next part of this work an example of the model for the organization and management of industrial enterprises is shown, in which the integration of its functions is emphasized, thus allowing the management structure of enterprise continuous monitoring of key parameters of results as well as their decision-making for continuous improvement and development.

In the specific example of a complex industrial enterprise it is shown that a number of defined areas of work – functions of the company which in harmonic, integrative effect enable the implementation of all necessary processes.

The model is adapted to complex industrial company through the elaboration of the concept of Balanced Scorecard (BSC) and identification of key performance indicators (KPIs) in the financial perspective, a perspective of buyer / customer, internal process perspective and the perspective of learning and development.

Thus defined model of key performance of complex industrial enterprise provides an independent view of each process and defines key performance indicators for all processes.

APPLICATION OF DEVELOPED KEY PERFORMANCE MODEL IN AN INDUSTRIAL COMPANY

Model for the measurement of key performance indicators is applied on the real example of the complex industrial company with different areas of activity for period of one year (Đurić et al., 2010).

Structure of the identified processes in the analyzed company is shown in Table 1 and Figure 1.

The structure of the identified processes and their interconnections is shown by the process model using an example of the complex industrial enterprise (Figure 1), which consists of the following groups of processes:

i. Management processes
ii. Realization processes
iii. Support processes
iv. Measuring and improvement processes.

In the above example of the complex industrial enterprise, each functional activity has its own specific work processes that are managed in a manner that ensures stable mutual linkages, whose goal is to work effectively within the whole.

BALANCE SCORECARD IN A COMPLEX INDUSTRIAL ENTERPRISE

Practical implementation of Balanced Scorecard concept, suggests the need to adjust to the nature and characteristics of the case (the area of business, size of company etc.), as shown in Figure 2 (Đurić et al., 2010).
In the practical implementation of applying of Balanced Scorecard concept it is necessary to identify key performance indicators for companies in all four areas of observation, with clearly outlined need that measurement in these areas of observation is standardized to a level that ensures the needs of company - without "burdening" with the concepts of financial, technical or nonfinancial.

In this industrial company a system of managing performance and goals is established, that is, a system for making, measuring and controlling the achieved goals.

Access to concretization of key performances of the process in case of joint-stock company (Figure 3), is based on experiences in the application of process approach according to ISO 9000 standards.

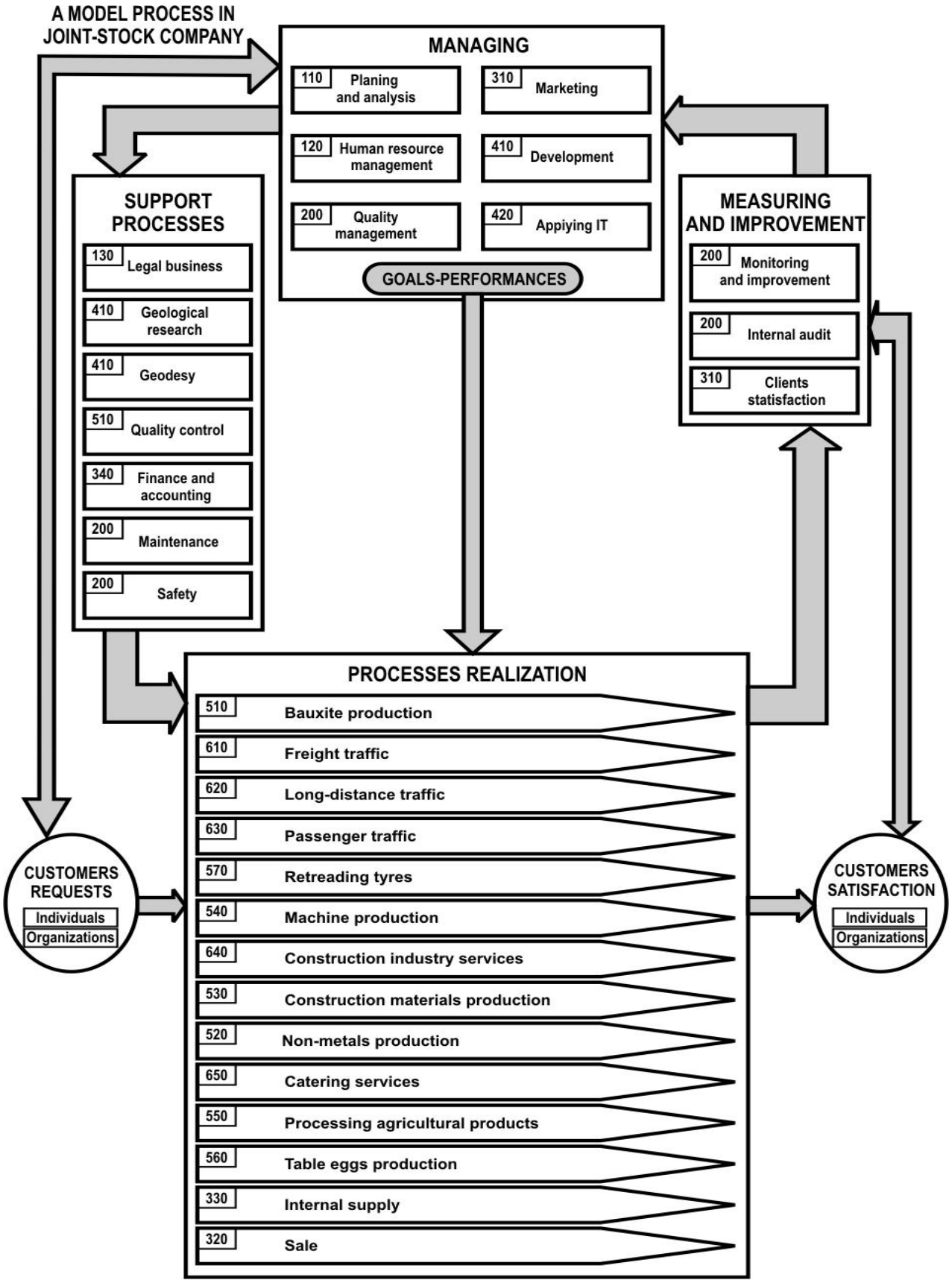

Figure 1. A process model in real complex enterprise (Đurić et al., 2010).

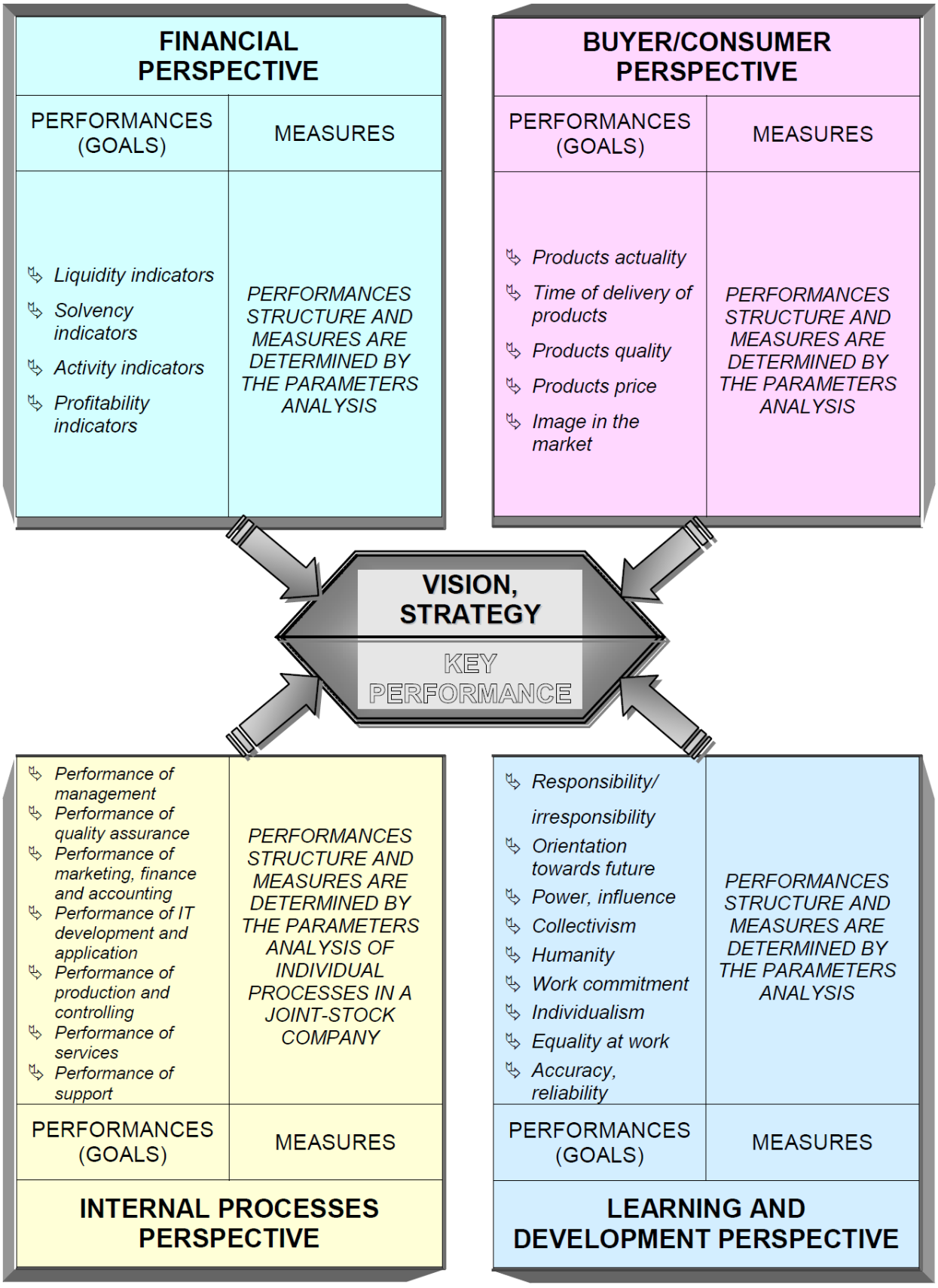

Figure 2. Development of the balanced scorecard concept – [Adapted from Kaplan and Norton (1999, 2001)].

FINANCIAL PERSPECTIVE	
PERFORMANCES (GOALS)	MEASURES
Ability to survive	*Positive cash flow*
Ability to endure	*Steady sales growth and revenue*
Ability to develop	*Permanent market share growth, return on investment (ROI) and economic value added (EVA)*

BUYER/CONSUMER PERSPECTIVE	
PERFORMANCES (GOALS)	MEASURES
Products actuality	*Share of new products in total sales*
Responsibility in delivery	*Timely delivery percentage*
Being a preferred supplier	*Participation in buyers key supplies*
To be a partner	*Number of cooperative contracts with buyers*

INTERNAL PROCESSES PERSPECTIVE	
PERFORMANCES (GOALS)	MEASURES
Technological competitiveness	*Capacity, equipment performance, contemporarity*
Production excellence	*Production cycle, cost, profit*
Development excellence	*Idea to market time*
Development ability	*Share of new products in program*

LEARNING AND DEVELOPMENT PERSPECTIVE	
PERFORMANCES (GOALS)	MEASURES
Employees competitivity	*New generation development time*
Learning ability	*Time for maturity of company processes*
Commitment to company	*Employees leaving company percentage*
Leading ability	*Leadership characteristics*

Figure 3. The balanced scorecard concept adapted to the joint-stock company (Djuric et al., 2010).

KEY PERFORMANCE INDICATORS IN THE JOINT-STOCK COMPANY

In this case, key performances of the joint-stock company viewed from the perspective of internal processes, in terms of their structure and performance measures, are determined by the analysis of parameters of individual processes and *key performance indicators* that are used

Table 2. Map of key performances of process 110 - Planning and Analysis.

QUALITY PROCESS CHARACTERISTICS 110 - PLANNING AND ANALYSIS			**PROCESS GOALS MEASURING RESULTS 110 - PLANNING AND ANALYSIS**				
Plan realization incompatibility index	**Plan development delay index**	**Analysis development delay index**	Process characteristics				
$IO_p = \frac{D_p - O_p}{D_p} \times 100$ [%]	$IK_{ip} = 100 - \frac{t_{prok} - t_{kr}}{t_{prok}} \times 100$ [%]	$IK_{ia} = 100 - \frac{t_{arok} - t_{ka}}{t_{arok}} \times 100$ [%]	IO_p	IK_{ip}	IK_{ia}		
where:	where:	where:	66	27	18	Process characteristics values	
IOp - plan realization incompatibility index in a given period,	IKip- plan development delay index in a given period,	- business analysis development delay index in a given period,	100	10	10	10	Process characteristics rating scale
Dp- value defined for the process plan in a given period,	t_{proi}- deadline for plan development in a given period,	- The set deadline set on business analysis development in a given period,	90	20	20	9	
Op - deviation from the defined plan.	t_{ir}- time delay in plan development after plan development deadline	- time delay in business analysis development after business analysis development deadline	80	30	30	8	
			70	40	40	7	
Data sources							
QO.110-00/104 – Business realization record; Information system: - Business realization;	QO.110-00/104 - Business realization record; Information system: - Business realization;	Information system: - Annual business analysis report; - Business performance indicators;	7	8	9		Grade O
			4	3	3		Ponder P
			28	24	27		Points = OxP
			Total points				79
			40	30	30		100% max goalvalue
			Goal accomplishment percentage				79%
			60	50	50	6	
			50	60	60	5	
			40	70	70	4	
			30	80	80	3	
			20	90	90	2	
			<10	100	100	1	

in this joint-stock company are presented.

Bearing in mind that the presented perspectives of processes and approach to concretization of key performances of process are adapted to the industrial enterprise, it should be emphasized that the model for the measurement of key performance indicators, is used for detailed definition of performances of internal processes.

In this sense, the *map of key performances of process* (Đurić et al., 2010) was used for conducting an analysis of the internal process by checking the developed model for the measurement of key performance indicators of the joint-stock company.

In continuation of this work the developed maps of key performances for specific processes will be represented as shown in Tables 2 to 7 which are selected as samples.

It is about the following processes of the sample industrial enterprise as follows:

i. process of planning and analysis (110);
ii. process of sales (320);
iii. process of supply (330);

Table 3. Map of key performance of process 320 – Sale.

QUALITY PROCESS CHARACTERISTICS 320 - SALE

Sold products quality index	Timely sale index	Buyer contact realization index
$IQ = 101 - \frac{\sum_{i=1}^{3} F_{ti} \times n_i}{N}$ where: IQ – sold products quality index in a given period, F_{ti} – quality factor of deliveries output products compared to their quality, n_i - number of deliveries with the same significance factor for determined quality, N - total number of deliveries of output products in a given period. F_{ti} - Delivery quality 1 - For deliveries done without or with minor deficiencies 50 - For deliveries done with significant deficiencies 100 - For rejected deliveries	$IBI_n = \frac{UVI_n^1}{N}$ where: IBI_n – timely sale index, UVI^1_n – number of delayed product deliveries in a given period, N - total number of product deliveries in a given period	$IK_n = \frac{PK_n^1}{N}$ where: IK_n – buyer contact realization index, PK^1_n - the number of realized contacts in a given period, N - total number of planned contacts in a given period.
Data sources		
F_{ti}, n_i, N: **QO.320-00/105** - Sale realization record	UVI^1_n, N: **QO.320-00/105** - Sale realization record	Information system: PK^1_n, N: **QO.320-00/101** - Buyer contact record **QO.320-00/105** - Sale realization record

PROCESS GOALS MEASURING RESULTS 320 - SALE

Process IQ	Process IBI_i	Process IK_n	Process characteristics values	
76	**0.32**	**0.9**		
100	0.1	0.5	10	Process characteristics rating scale
90	0.2	0.6	9	
80	**0.3**	0.7	8	
70	0.4	0.8	7	
60	0,5	**0.9**	6	
50	0.6	1.0	5	
40	0.7	1.1	4	
30	0.8	1.2	3	
20	0.9	1.3	2	
10	1.0	1.4	1	
8	8	6		Grade O
4	3	3		Ponder P
32	24	18		Points = OxP
Total points				**74**
40	30	30		100% max goalvalue
Goal accomplishment percentage				**74%**

Table 4. Map of key performance of process 330 – Supply.

QUALITY PROCESS CHARACTERISTICS 330 - SUPPLY

Purchased products quality index

$$IQ = 101 - \frac{\sum_{i=1}^{3} F_{ti} \times n_i}{N}$$

where:

IQ - an index of quality of products purchased in this period,

F_{ti} - factor of the input supply products in relation to their quality,

n_i - number of deliveries to the same factor of significance for a fixed quality,

N-total number of incoming product deliveries in the period.

F_{ti}	- Delivery quality
1	- For deliveries done without or with minor deficiencies
50	- For deliveries done with significant deficiencies
100	- For rejected deliveries

Timely purchase index

$$IB_n = \frac{UV_n^1}{N}$$

where:

IB_n - timely supply index,

UV^1_n - number of delayed supplies of input products in a given period

N - total input product deliveries in a given period

Supply cost index

$$IT_n = \frac{UT_n}{V_p} \times 100\,[\%]$$

IT_n – supply cost index

UT_n – total supply cost index in a given period

V_p – sale value in a given period

Data sources

F_{ti}, n_i, N: ***QO.330-00/108***
- Supply realization record

UV^1_n, N: ***QO.330-00/108***
- Supply realization record

UT_n: ***QO.330-00/108***
- Supply realization record
V_p: ***QP.320-00/105***
- Sale realization record

PROCESS GOALS MEASURING RESULTS 330 - SUPPLY

Process characteristics IQ	IB_i	IT_n		
68	**0.9**	**20**	Process characteristics	
100	0.5	5	10	Process characteristics rating scale
90	0.6	10	9	
80	0.7	15	8	
70	0.8	**20**	7	
60	**0.9**	25	6	
50	1.0	30	5	
40	1.1	35	4	
30	1.2	40	3	
20	1.3	45	2	
10	1.4	50	1	
7	6	7	Grade O	
5	2	3	Ponder P	
35	12	21	Points = OxP	
Total points			**68**	
50	20	30	100% max goal value	
Goal accomplishment percentage			**68%**	

Table 5. Map of key performance of process 410 - Products and services development.

QUALITY PROCESS CHARACTERISTICS 410 – PRODUCTS/SERVICES DEVELOPMENT

Project quality	Project realization speed	Number of implemented projects
Measured as the ratio of non-coordinated in relation to the total number of implemented projects in a given period: $B_{np} = \frac{b_{np}}{b_{rp}} \times 100\,[\%]$ *where:* B_{np} *-% non-coordinated projects in a given period,* b_{NP} *- total number of non-compliant projects in a given period,* b_{rp} *- total number of projects (coordinated and non-coordinated) in the same period. Non-compliance of the project determined by its revision and necessity for corrections. As uncoordinated are considered all the projects which were not accepted in the audit process, although they were later repaired and subsequently passed the audit.*	*It is measured as the ratio of the deadline for the project and the total duration of the project in a given period:* $V_{rp} = \frac{t_{rok}}{t_{tp}}$ *where:* V_{rp} *- the speed of project implementation in a given period,* t_{rok} *- the deadline for the project implementation in a given period,* t_{tp} *- total duration of the project in a given period.*	*Viewed as the ratio of the number of implemented projects in a given period compared to the number of implemented projects in the previous period:* $B_{rp} = \frac{b_{rp}^{pp}}{b_{rp}^{pp-1}} \times 100\,[\%]$ *where:* B_{rp} *-% increase and decrease of implemented projects in a given period compared to the previous,* b^{pp}_{rp} *- number of implemented projects in a given period,* $b^{pp\text{-}1}_{rp}$ *- number of implemented projects in the previous period.*

PROCESS GOALS MEASURING RESULTS 410 – PRODUCTS/SERVICES DEVELOPMENT

Process characteristics			
B_{np}	V_{rp}	B_{rp}	
18	**1.16**	**21**	Process characteristics
10	2.00	>110	10
20	1.50	100	9
30	1.25	**95**	8
40	**1.10**	90	7
50	1.00	85	6
60	0.80	80	5
70	0.60	75	4
80	0.40	70	3
90	0.20	65	2
100	0.00	60	1

Process characteristics rating scale

9	7	8	Grade O
3	4	3	Ponder P
27	28	24	Points = OxP
Total points			**79**
30	40	30	100% max goalvalue
Goal accomplishment percentage			**79%**

Table 6. Map of key performance of process 510 - bauxite production.

QUALITY PROCESS CHARACTERISTICS 510 – BAUXITE PRODUCTION

Plan realization incompatibility index

$$IQ_P = 101 - \frac{\sum_{i=1}^{n} F_{zi} \times n_i}{N}$$

where:

IQ_p - bauxite ore quality index

F_{zi} – product incomparability significance factor

n_i - amount of bauxite ore with the same significance factor

N - total ore amount

F_{zi}	Description
1	*- Ore - bauxite sent without incomprability*
50	*- Ore - bauxite sent with minor incomparabilities that did not affect the final reception*
100	*- Ore - bauxite declined on the final reception*

Plan development delay index

$$IV_i = \frac{V_i^u}{V_i^p}$$

where:

IV_i – exploitation time index ore - bauxite in a given period

V^{u}_i - total spent time used for the exploitation total ore amount in a given period

V_i^p - total planned time for exploitation of total planned ore - bauxite amount in the same period

Analysis development delay index

$$IT_i = \frac{T_i^u}{T_i^p} \times 100[\%]$$

where:

IT_i – exploitation cost index

T^{u}_i – total exploitation cost in planned period

T^{p}_i – total exploitation planned cost in a given period

Data sources

QO.510-00/105 *– Quality record ore - bauxite*

- Record of the operational worker on the control and homogenization plateau

QO.110-00/102 *– Annual production plan ore - bauxite*

- Buyers contract

-Working account - Information System

-Working account - book record - Information System

*- **QO.320-00/102***

-Sales realization record

PROCESS GOALS MEASURING RESULTS 510 – BAUXITE PRODUCTION

Process characteristics				
IQ_p	IV_i	IT_i		
88	**1.16**	**23**	Process characteristics	
100	0.9	10	10	Process characteristics rating scale
90	1	**20**	9	
80	1.1	30	8	
70	**1.2**	40	7	
60	1,3	50	6	
50	1.4	60	5	
40	1.5	70	4	
30	1.6	80	3	
20	1.7	90	2	
10	1.8	100	1	
9	7	9	Grade O	
3	4	3	Ponder P	
27	28	27	Points = OxP	
Total points			**82**	
30	40	30	100% max goal value	
Goal accomplishment percentage			**82%**	

Table 7. Map of key performance of process 610 - freight traffic.

QUALITY PROCESS CHARACTERISTICS 610 – FREIGHT TRAFFIC		
Freight traffic service quality index	**Freight traffic service time index**	**Freight traffic service cost index**
$IQ = 101 - \frac{\sum_{i=1}^{3} F_{ti} \times n_i}{N}$ *where:* *IQ – freight traffic service quality index in a given period,* *F_{ti} – service quality factor compared to its quality,* *n_i – number of services with the same significance factor for the quality* *N - total number of freight traffic services in a given period* *F_{ti}* - Quality of delivery *1* - *For services carried without or with minor incomperabilities* *50* - *For services that are performed with huge incomperability* *100* - *For rejected services*	$IV_i = \frac{V_i^u}{V_i^p}$ *where:* *IV_i – freight traffic service time index in a given period* *V_i^u - the total time spent for the total freight traffic services in a given period* *V_i^p - total planned time for all freight traffic services in the same period*	$IT_i = \frac{T_i^u}{T_i^p} 100\,[\%]$ *where:* *IT_i – freight traffic service cost index* *T^u_i - total costs of freight traffic services within the planned period,* *T^p_i - the total planned cost of freight traffic services in a given period.*
Data sources		
F_{ti}, n_i, N: ***QO.320-00/105*** *- sales record;*	- ***QO.110-00/102*** *- Annual record of freight traffic services*; *- Buyer contracts*; *- Working account- Information System*	*- Working account- book records - Information System*; - ***QO.320-00/102*** *- sales record*

PROCESS GOALS MEASURING RESULTS 610 – FREIGHT TRAFFIC

Process			
IQ	IV_i	IT_i	
77	**1.32**	**21**	Process
100	0.9	10	10
90	1	**20**	9
80	1.1	30	8
70	1.2	40	7
60	**1.3**	50	6
50	1.4	60	5
40	1.5	70	4
30	1.6	80	3
20	1.7	90	2
10	1.8	100	1
			Process characteristics rating scale
8	6	9	Grade O
4	3	3	Ponder P
32	18	27	Points = OxP
Total points			**77**
40	30	30	100% max goal value
Goal accomplishment percentage			**77%**

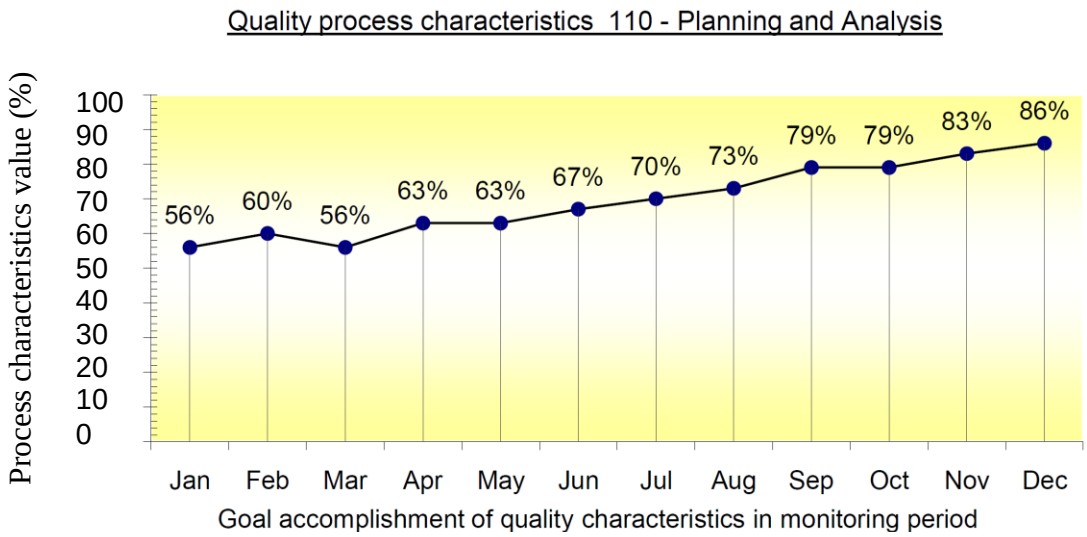

Figure 4. Trend of changes in achieving the goal of quality characteristics of process 110 - Planning and Analysis.

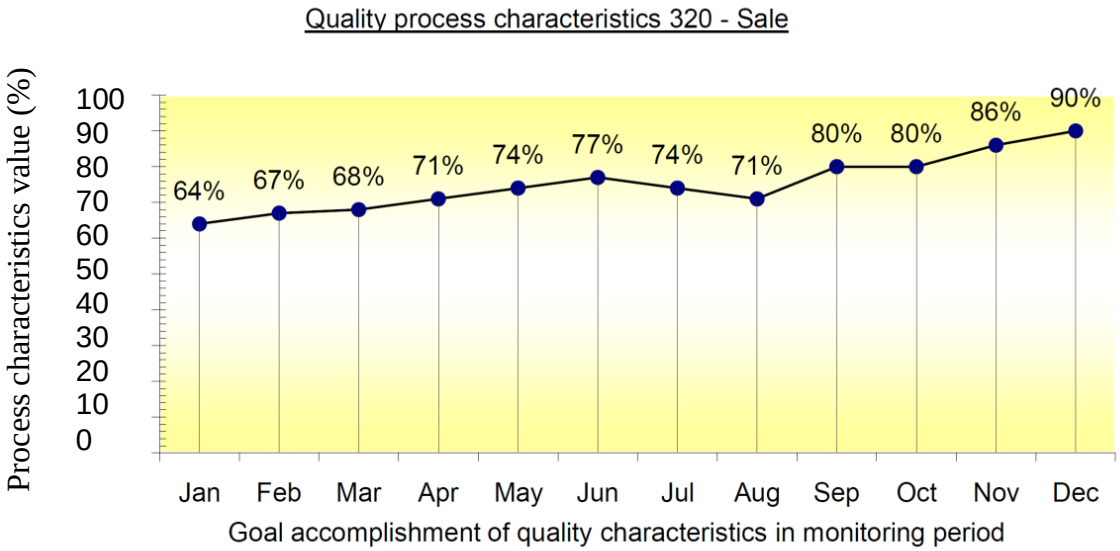

Figure 5. Trend of changes in achieving the goal of quality characteristic of process 320 – Sale.

iv. process of products/services developing (410);
v. process of bauxite production (510);
vi. process of freight traffic (610).

ANALYSIS OF RESULTS OF APPLICATION OF KEY PERFORMANCE MODEL

Detailed check of applying an elaborated model of key performances of the sample company was carried out in accordance with the analysis of results of applying the model for measuring key performance indicators for a period of one year.

All the processes defined and presented in the charts in Figures 4 to 9 correspond to Tables 8 to 13 which are the analysis of the results of application of the developed model of key performances of process in the sample joint-stock company for the year 2009.

Review of the total goal accomplishment for individual processes in the sample industrial company is shown in Figure 10.

Analyses of the presented results of measuring the process goals in the sample industrial company indicate the state of performances of individual processes, and they are used as input for the process of reviewing the company effectiveness by the management, which

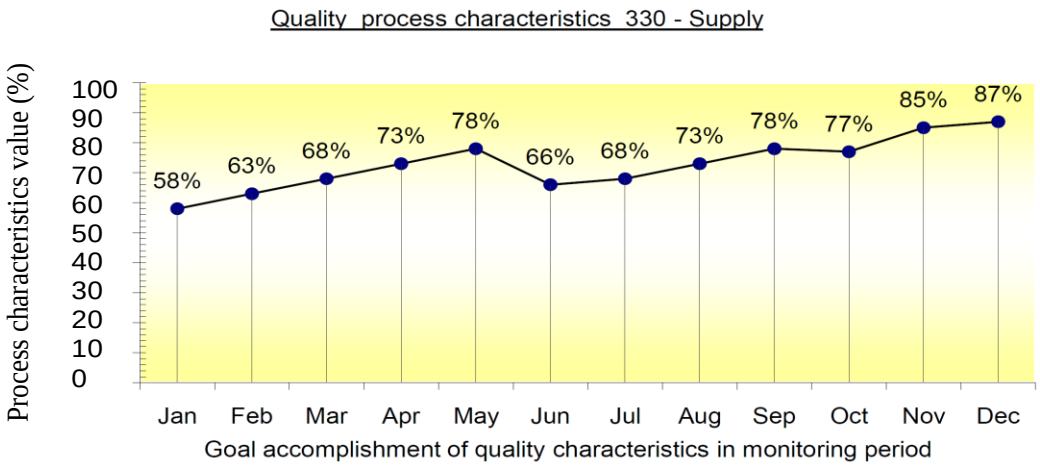

Figure 6. Trend of changes in achieving the goal of quality characteristic of process 330 – Supply.

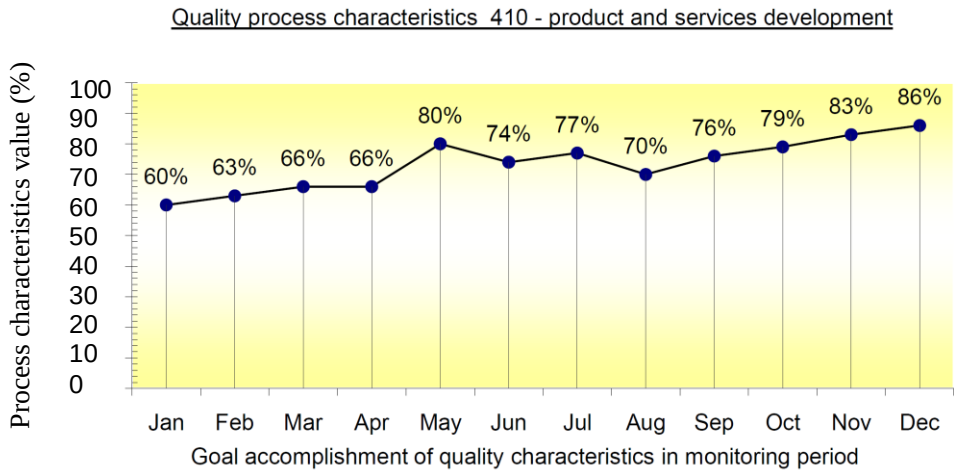

Figure 7. Trend of changes in achieving the goal of quality characteristic of process 410 - Product and Service development.

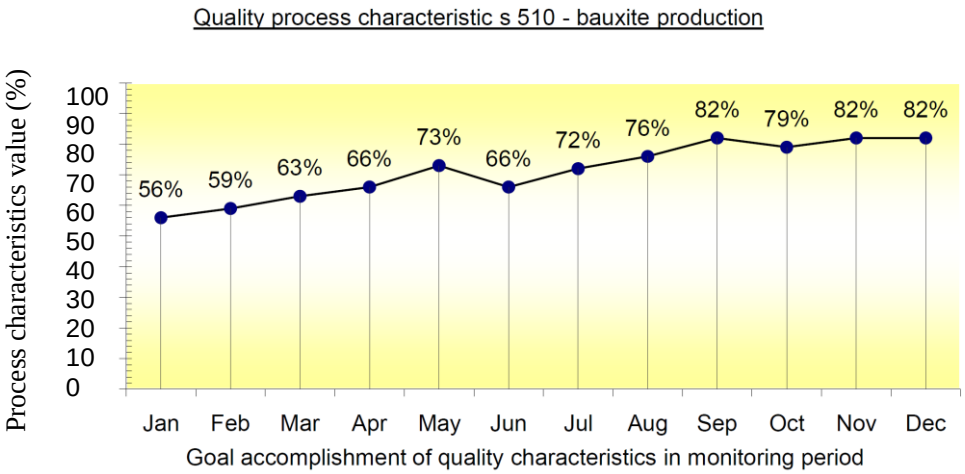

Figure 8. Trend of changes in achieving the goal of quality characteristic of process 510 – Bauxite production.

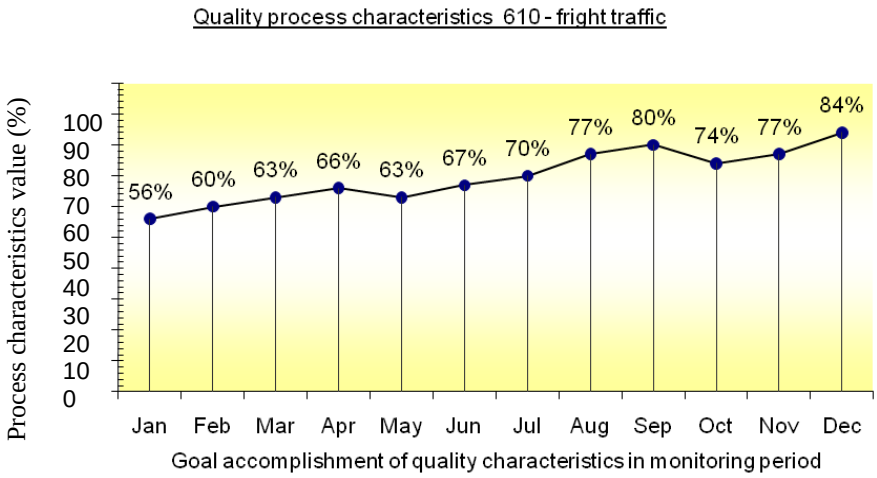

Figure 9. Trend of changes in accomplishing goal of quality characteristic of process 610 - Freight traffic.

Table 8. Process goals measuring results 110 - Planning and Analysis in the monitoring period.

Process key performance – 110 – Planning and analysis												
Quality process characteristics	**(January - 2009)**			**(February - 2009)**			**(March - 2009)**			**(April - 2009)**		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Plan realization incompatibility index	52	(5x4) 20	**56%**	56	(6x4) 24	**60%**	54	(5x4) 20	**56%**	61	(6x4) 24	**63%**
Plan development delay index	56	(5x3) 15		58	(5x3) 15		60	(5x3) 15		54	(6x3) 18	
Analysis development delay index	38	(7x3) 21		37	(7x3) 21		37	(7x3) 21		43	(7x3) 21	
Quality process characteristics	**(May - 2009)**			**(Jun - 2009)**			**(July - 2009)**			**(August - 2009)**		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Plan realization incompatibility index	63	(6x4) 24	**63%**	66	(7x4) 28	**67%**	68	(7x4) 28	**70%**	70	(7x4) 28	**73%**
Plan development delay index	53	(6x3) 18		54	(6x3) 18		48	(6x3) 18		44	(7x3) 21	
Analysis development delay index	40	(7x3) 21		39	(7x3) 21		34	(8x3) 24		32	(8x3) 24	
Quality process characteristics	**(September -2009)**			**(October -2009)**			**(November -2009)**			**(December -2009)**		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Plan realization incompatibility index	66	(7x4) 28	**79%**	72	(7x4) 28	**79%**	79	(8x4) 32	**83%**	76	(8x4) 32	**86%**
Plan development delay index	27	(8x3) 24		30	(8x3) 24		26	(8x3) 24		24	(9x3) 27	
Analysis development delay index	18	(9x3) 27		22	(9x3) 27		21	(9x3) 27		19	(9x3) 27	
Total goal accomplishment of quality process characteristics – 110 in 2009:										**69%**		

V_{kp} – Process characteristics value;
BP_{kp} – Number of process characteristics points (multiplication of process grade and ponder);
OC_p – Process goal accomplishment in the monitoring period (Σ BP_{kp}) [%].

Table 9. Results of measurements of the goals of the process 320 - Sales in the observed period.

Process key performance – 320 – Sale												
Quality process characteristics	**(January - 2009)**			**(February - 2009)**			**(March - 2009)**			**(April - 2009)**		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Sold products quality index	69	(7x4) 28	**64%**	72	(7x4) 28	**67%**	76	(8x4) 32	**68%**	78	(8x4) 32	**71%**
Timely sale index	0.42	(7x3) 21		0.39	(7x3) 21		0.37	(7x3) 21		0.41	(7x3) 21	
Buyer contact realization index	1.0	(5x3) 15		0.9	(6x3) 18		1.0	(5x3) 15		0.9	(6x3) 18	
Quality process characteristics	**(May - 2009)**			**(Jun - 2009)**			**(July - 2009)**			**(August - 2009)**		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Sold products quality index	76	(8x4) 32	**74%**	80	(8x4) 32	**77%**	83	(8x4) 32	**74%**	79	(8x4) 32	**71%**
Timely sale index	0.32	(8x3) 24		0.28	(8x3) 24		0.27	(8x3) 24		0.26	(8x3) 24	
Buyer contact realization index	0.9	(6x3) 18		0.8	(7x3) 21		0.9	(6x3) 18		1.0	(5x3) 15	
Quality process characteristics	**(September - 2009)**			**(October - 2009)**			**(November - 2009)**			**(December - 2009)**		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Sold products quality index	84	(8x4) 32	**80%**	81	(8x4) 32	**80%**	83	(8x4) 32	**86%**	86	(9x4) 36	**90%**
Timely sale index	0.24	(9x3) 27		0.27	(8x3) 24		0.21	(9x3) 27		0.23	(9x3) 27	
Buyer contact realization index	0.8	(7x3) 21		0.7	(8x3) 24		0.6	(9x3) 27		0.6	(9x3) 27	
Total goal accomplishment of quality process characteristics – 320 in 2009:										**75%**		

V_{kp} – Process characteristics value;
BP_{kp} – Number of process characteristics points (multiplication of process grade and ponder);
OC_p – Process goal accomplishment in the monitoring period ($\Sigma\ BP_{kp}$) [%].

secures information for improving the performances of the company as a whole. Practically, the analysis of measurement the process goals allows the identification *of "critical points"* in each process based on lower assessment of the quality characteristic of key performance indicators of the process, and then it allows comparing to the planned and the performance of competing companies, so as to thereby identify areas for process improvement.

Analysis of the results contributed to establishing the root causes of existing or potential problems, and thus represents a source for initiating corrective and preventive measures.

All the characteristics of the process are measurable, thus providing transparency and particularity in data analysis.

Availability of information indicating the status of the process directly or indirectly, as already noted, is the requirement for taking action to improve process performance.

DISCUSSION

In order to successfully measure the operating efficiency of this complex industrial enterprise, and to raise the level of quality in the individual business processes, it was necessary that special attention is paid to the application of new approaches to management - in the conceptual and organizational sense. It was necessary to provide a tool with which the management of company, in a balanced way, reaches the level necessary to meet demands of all stakeholders.

The process of continuous extraction, processing and analysis of data is systematically performed, in order to obtain relevant information regarding the work process in the entire company.

A key result of the research is that application of the

Table 10. Results of measurements of the goals of process 330 - Supply in the monitoring period.

Process key performance – 330 – Supply												
Quality process characteristics	**(January - 2009)**			**(February - 2009)**			**(March - 2009)**			**(April - 2009)**		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Purchased products quality index	62	(6x5) 30	**58%**	64	(6x5) 30	**63%**	68	(7x5) 35	**68%**	72	(7x5) 35	**73%**
Timely purchase index	1.0	(5x2) 10		0.9	(6x2) 12		0.9	(6x2) 12		0.8	(7x2) 14	
Supply cost index	26	(6x3) 18		22	(7x3) 21		20	(7x3) 21		16	(8x3) 24	
Quality process characteristics	**(May - 2009)**			**(Jun - 2009)**			**(July - 2009)**			**(August - 2009)**		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Purchased products quality index	76	(8x5) 40	**78%**	74	(7x5) 35	**66%**	74	(7x5) 35	**68%**	76	(8x5) 40	**73%**
Timely purchase index	0.8	(7x2) 14		1.0	(5x2) 10		0.9	(6x2) 12		0.9	(6x2) 12	
Supply cost index	15	(8x3) 24		18	(7x3) 21		20	(7x3) 21		19	(7x3) 21	
Quality process characteristics	**(September - 2009)**			**(October - 2009)**			**(November - 2009)**			**(December - 2009)**		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Purchased products quality index	82	(8x5) 40	**78%**	84	(8x5) 40	**77%**	86	(9x5) 45	**85%**	88	(9x5) 45	**87%**
Timely purchase index	0.8	(7x2) 14		0.7	(8x2) 16		0.7	(8x2) 16		0.6	(9x2) 18	
Supply cost index	15	(8x3) 24		18	(7x3) 21		16	(8x3) 24		14	(8x3) 24	
Total goal accomplishment of quality process characteristics – 330 in 2009:										**73%**		

V_{kp} – Process characteristics value;
BP_{kp} – Number of process characteristics points (multiplication of process grade and ponder);
OC_p – Process goal accomplishment in the monitoring period ($\Sigma\ BP_{kp}$) [%].

model of key performance of complex industrial enterprise contributes to increasing level of process characteristics, and their joint effects, which can also be used for defining BSC for the complex industrial enterprise.

Establishing a system of consistent criteria - parameters (performance) of processes in the company, made it possible to increase the effectiveness of these processes and overall business success there. During the period in which the analysis was conducted, the basic parameters (performance) of the observed internal processes had sufficient size and positively oriented trend that is reflected in the need of applying a strategy of rapid development of new capacities of industrial enterprise and its global expansion. The obtained results of the analysis provide information on the need of applying more aggressive strategy for growth and development of the observed company.

CONCLUSION

The survey, whose results are presented in this paper, represents a concrete contribution to the application of management methods intended for measuring the business success of complex industrial enterprise.

An important component of the developed model, which measures the success of the business by reaching the strategic goals, are the quality characteristics of processes and key performance indicators of process, which are again base for an industrial company to learn from the past experience and introduce changes for improving process performances in the future.

Starting from the findings that have been reached in this study, it is possible to draw conclusions that point to such a solution which should ensure a way of settling problems that occur in the system of establishing and managing key performance indicators used to measure,

Table 11. Results of measurements of the goals of process 410 - Products and services development in the monitoring period.

Process key performance – 410 – Products and services development												
Quality process characteristics	(January - 2009)			(February - 2009)			(March - 2009)			(April - 2009)		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Project quality	52	(6x3) 18	**60%**	46	(6x3) 18	**63%**	42	(7x3) 21	**66%**	38	(7x3) 21	**66%**
Project realization speed	1.00	(6x4) 24		1.02	(6x4) 24		1.04	(6x4) 24		1.01	(6x4) 24	
Number of implemented projects	86	(6x3) 18		89	(7x3) 21		90	(7x3) 21		91	(7x3) 21	
Quality process characteristics	(May - 2009)			(Jun - 2009)			(July - 2009)			(August - 2009)		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Project quality	34	(8x3) 24	**80%**	36	(7x3) 21	**74%**	33	(8x3) 24	**77%**	38	(7x3) 21	**70%**
Project realization speed	1.18	(8x4) 32		1.20	(8x4) 32		1.18	(8x4) 32		1.14	(7x4) 28	
Number of implemented projects	94	(8x3) 24		92	(7x3) 21		90	(7x3) 21		89	(7x3) 21	
Quality process characteristics	(September -2009)			(October -2009)			(November -2009)			(December -2009)		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Project quality	28	(8x3) 24	**76%**	18	(9x3) 27	**79%**	21	(9x3) 27	**83%**	18	(9x3) 27	**86%**
Project realization speed	1.12	(7x4) 28		1.16	(7x4) 28		1.20	(8x4) 32		1.18	(8x4) 32	
Number of implemented projects	93	(8x3) 24		94	(8x3) 24		97	(8x3) 24		99	(9x3) 27	
Total goal accomplishment of quality process characteristics – 410 in 2009:										**73%**		

V_{kp} – Process characteristics value;
BP_{kp} – Number of process characteristics points (multiplication of process grade and ponder);
OC_p – Process goal accomplishment in the monitoring period ($\Sigma\ BP_{kp}$) [%].

Table 12. Results of measurements of the goals of process 510 – bauxite production in the monitoring period.

Process key performance – 510 – Bauxite production												
Quality process characteristics	**(January - 2009)**			**(February - 2009)**			**(March - 2009)**			**(April - 2009)**		
	V_{kp}	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***
Product quality index - bauxite ore	72	(7x3) 21	**56%**	69	(7x3) 21	**59%**	73	(7x3) 21	**63%**	76	(8x3) 24	**66%**
Exploitation time - bauxite ore	1.42	(5x4) 20		1.39	(5x4) 20		1.34	(6x4) 24		1.30	(6x4) 24	
Exploitation cost - bauxite ore	56	(5x3) 15		51	(6x3) 18		48	(6x3) 18		46	(6x3) 18	
Quality process characteristics	**(May - 2009)**			**(Jun - 2009)**			**(July - 2009)**			**(August - 2009)**		
	V_{kp}	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***
Product quality index - bauxite ore	79	(8x3) 24	**73%**	74	(7x3) 21	**66%**	78	(8x3) 24	**72%**	84	(8x3) 24	**76%**

Table 12. Contd.

Exploitation time - bauxite ore	1.24	(7x4) 28		1.27	(6x4) 24		1.30	(6x4) 24		1.21	(7x4) 28	
Exploitation cost - bauxite ore	40	(7x3) 21		38	(7x3) 21		34	(8x3) 24		28	(8x3) 24	
Quality process characteristics	(September -2009)			(October -2009)			(November -2009)			(December -2009)		
	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p	V_{kp}	BP_{kp}	OC_p
Product quality index - bauxite ore	88	(9x3) 27	**82%**	83	(8x3) 24	**79%**	86	(9x3) 27	**82%**	87	(9x3) 27	**82%**
Exploitation time - bauxite ore	1.16	(7x4) 28		1.20	(7x4) 28		1.16	(7x4) 28		1.20	(7x4) 28	
Exploitation cost - bauxite ore	23	(9x3) 27		21	(9x3) 27		24	(9x3) 27		23	(9x3) 27	
Total goal accomplishment of quality process characteristics – 510 in 2009:										**71%**		

V_{kp} – Process characteristics value;
BP_{kp} – Number of process characteristics points (multiplication of process grade and ponder);
OC_p – Process goal accomplishment in the monitoring period ($\Sigma\ BP_{kp}$) [%].

Table 13. The results of measurements of the goals of process 610 - Freight traffic in the monitoring period.

Process key performance – 610 – Freight traffic												
Quality process characteristics	**(January - 2009)**			**(February - 2009)**			**(March - 2009)**			**(April - 2009)**		
	V_{kp}	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***
Freight traffic service quality index	54	(5x4) 20	**56%**	56	(6x4) 24	**60%**	61	(6x4) 24	**63%**	60	(6x4) 24	**66%**
Freight traffic service time index	1.42	(5x3) 15		1.44	(5x3) 15		1.34	(6x3) 18		1.31	(6x3) 18	
Freight traffic service cost index	44	(7x3) 21		41	(7x3) 21		37	(7x3) 21		34	(8x3) 24	
Quality process characteristics	**(May - 2009)**			**(Jun - 2009)**			**(July - 2009)**			**(August - 2009)**		
	V_{kp}	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***
Freight traffic service quality index	63	(6x4) 24	**63%**	66	(7x4) 28	**67%**	72	(7x4) 28	**70%**	77	(8x4) 32	**77%**
Freight traffic service time index	1.32	(6x3) 18		1.39	(5x3) 15		1.30	(6x3) 18		1.32	(6x3) 18	
Freight traffic service cost index	36	(7x3) 21		30	(8x3) 24		26	(8x3) 24		21	(9x3) 27	
Quality process characteristics	**(September - 2009)**			**(October - 2009)**			**(November - 2009)**			**(December - 2009)**		
	V_{kp}	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***	***V_{kp}***	***BP_{kp}***	***OC_p***
Freight traffic service quality index	76	(8x4) 32	**80%**	81	(8x4) 32	**74%**	84	(8x4) 32	**77%**	86	(9x4) 36	**84%**
Freight traffic service time index	1.24	(7x3) 21		1.27	(6x3) 18		1.19	(7x3) 21		1.21	(7x3) 21	
Freight traffic service cost index	24	(9x3) 27		28	(8x3) 24		26	(8x3) 24		23	(9x3) 27	
Total goal accomplishment of quality process characteristics – 610 in 2009:										**70%**		

V_{kp} – Process characteristics value;
BP_{kp} – Number of process characteristics points (multiplication of process grade and ponder);
OC_p – Process goal accomplishment in the monitoring period ($\Sigma\ BP_{kp}$) [%].

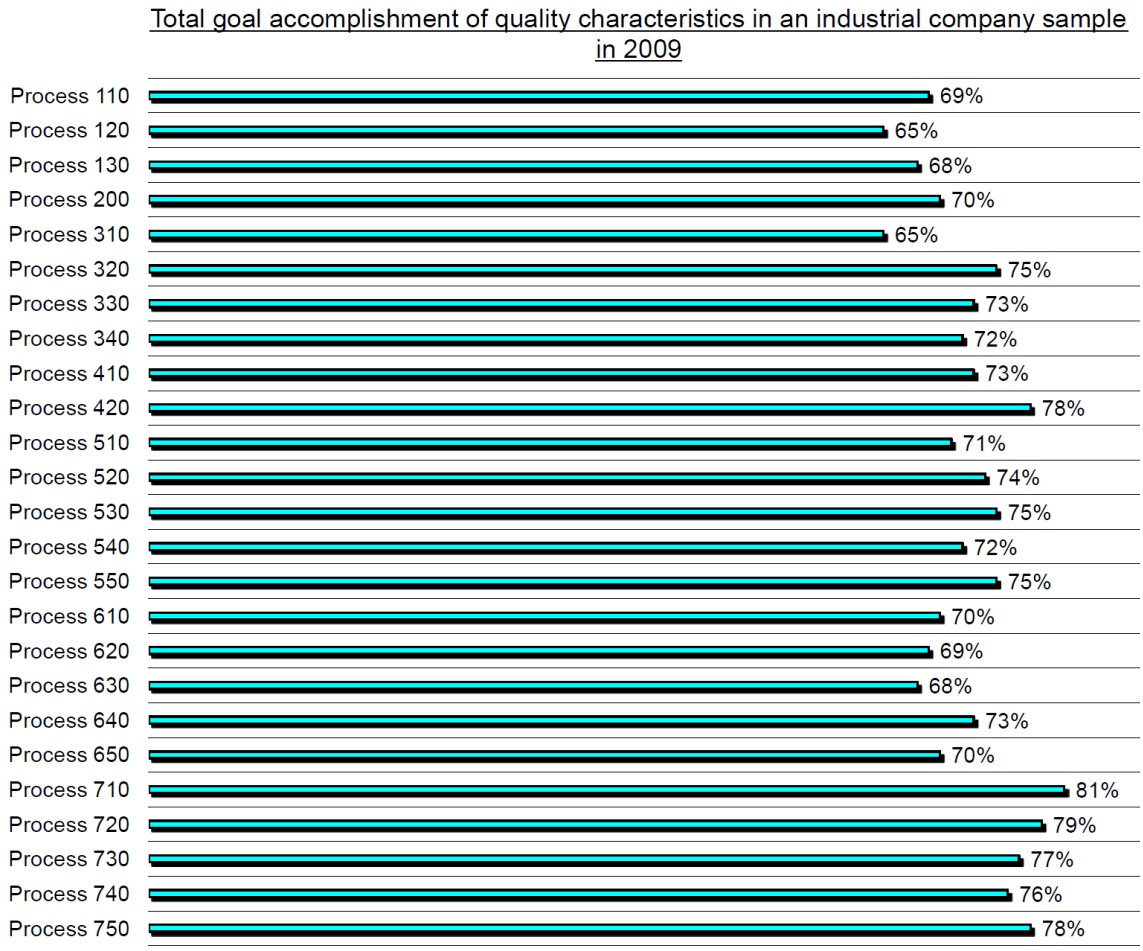

Figure 10. Review of the goal of quality characteristic of the process in the sample industrial enterprise for 2009.

monitor and manage business performance in the industrial company, in other words, determining the actual level of interdependence between the achieved quality of individual processes and indicators of effectiveness of the entire business enterprise. Achieving the integrity of certain perspectives or areas of the model of key performance of the industrial enterprise processes makes it possible to get insight into the important indicators of actual business results of enterprise, and determine which business processes should be improved and how to impact on their future design.

The development of company key performance model in already established perspectives helped in identifying critical factors and criteria for monitoring the achievement of strategic goals and measuring of the business resuts or the efficiency of complex industrial enterprise in the monitoring period.

Also, research in the framework of this study has shown that it is possible to establish a standardized system of criteria - parameters (performance) of the process, which in required and sufficient measure reflect the process effectiveness and the overall success of the industrial enterprise. A general model of key process performance is developed as a suitable tool for measuring and analysis of key performance indicators of work processes in industrial enterprise.

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