III-rd Section:

SCIENCE OF COMPLEXITY

THE QUALITY FUNCTION DEPLOYMENT (QFD) APPROACH IN THE REENGINEERING OF THE ENTERPRISE

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Abstract. *The present and future economic, social, technical etc. evolution requests for the modern enterprise to develop a complex structure of capabilities as: flexibility and adaptability to the external environment, fast responses to customers requests, fast developments of new products and services, competitiveness and leadership on the market, resources and costs optimizations, etc. One of the main recommended solutions for significant improvement of the enterprise's global behaviour is the reengineering of the enterprise. Also, risks in applying this solution exist beyond the human factor contributions at all the enterprise's levels.*

In order to create a framework the reengineering of the enterprise, that assures a positive and significant increase of the enterprise's performance and competitiveness, the present paper proposes the use of the QFD approach. The results obtained, will represent also contributions to the problem of complex management for the large variety of complex economic systems in the present context of globalisation.

Keywords**:** *reengineering, quality function deployment (QFD), competitiveness, global quality, life-cycle of the reengineered enterprise, goal oriented reengineering*

1. Introduction

The present conditions imposed to the enterprise's activities having as target its *competitiveness* correspond to a complex environment that requests a new functional structure able to **respond** and to adapt to a large diversity of problems.

In order to obtain in 'real time' such a structure, the reengineering solution may be applied to the enterprise, as the design of a new internal organization able to perform better its tasks, and to attain its goals [1]. This solution is process – oriented, such that al the enterprise's activities, viewed as events, form different dominant processes that are critical to the

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survival and to the evolution of the enterprise, and are related in a specific manner that can be represented in a process map.

If the natural causal relation between the enterprise's processes and its hierarchical and organizational structure is considered, then it becomes necessary that the structure must satisfy the accomplishment of the processes, and must respect the relations from the process map, without segmentation (i.e., the introduction of supplementary relations with the corresponding requirements due to the division of the dominant processes between the components of an imposed structure).

Thus, the reengineering of the enterprise represents the development of a new enterprise as a new structure whose elements are determined by the specific dominant processes and the process map, such that is created a framework necessary to perform simultaneously the processes, and to obtain the requested performance (figure 1).

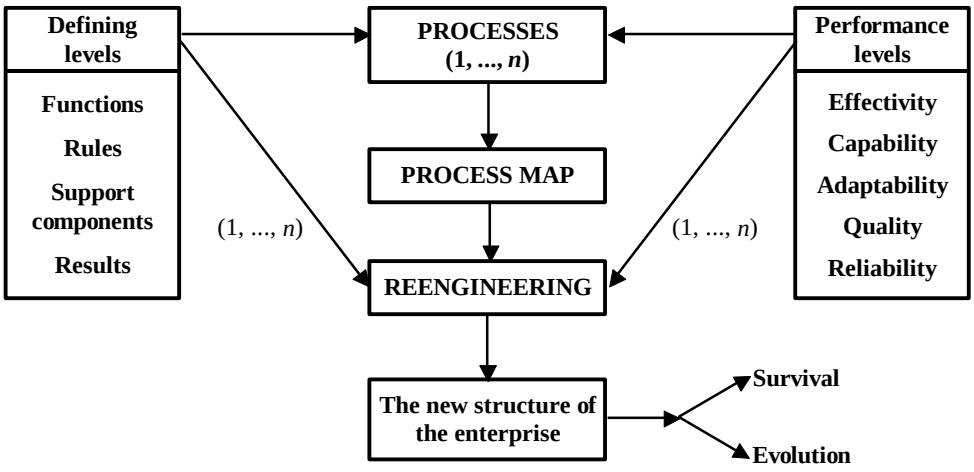

Figure 1. The framework for reengineering that considers the realization of the enterprise's processes at both definition and performance levels.

2. The enterprise's competitiveness as the reengineering result. The enterprise's global quality

Considering the goals of any enterprise regarding its survival and evolution in the external environment, results that the necessary processes that should be performed are the following:

a) the market analysis;
b) the product conception / research;
c) the product development and design;
d) the product implementation and manufacturing;
e) the promotion of the product on the markets;

f) the product delivery and selling;
g) the technical support and maintenance;
h) the management and decision process;
i) the business development;
j) the development of the enterprise's policy and strategies;
k) the information processing;
l) the control processes;
m) the communication processes;
n) the activities integration and coordination;
o) the learning and experiences accumulation.

Analyzing the above processes results that they can be integrated in the set of the dominant processes that will correspond to the enterprise's goals, and will concentrate the main activities without segmentation, as following:

A) the strategic development process;
B) the product development;
C) the design for the client's requests and support;
D) the response to delivery and selling requests;
E) the communication with the clients / users, and the enterprise's suppliers;
F) the internal capabilities development.

Thus, the dominant and auxiliary process **a ÷ o** are integrated in the new dominant processes **A ÷ F** as in figure 2.

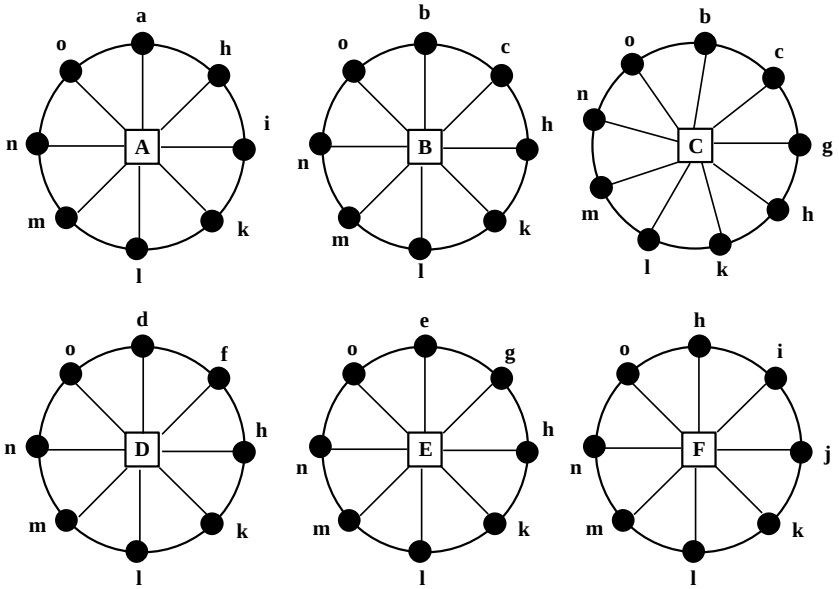

Figure 2. The integration of the processes **a ÷ o** in the new dominant processes **A ÷ F**.

According to the above determined new dominant processes, and considering the relations between them, the corresponding process map of the enterprise will be developed as in figure 3 where one possible solution is presented.

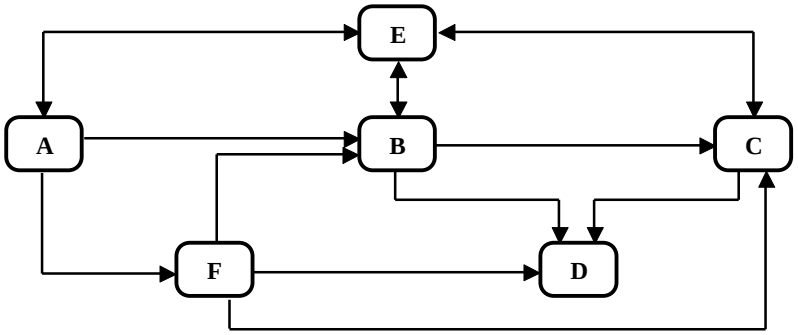

Figure 3. One possible process map for the dominant processes **A ÷ F**.

The dominant processes **A ÷ F** and the process map represent the basis for the development of the new organizational structure of the enterprise, such that a new enterprise is built, with the following main aspects of its competitiveness:

1. The enterprise becomes goal oriented at all its internal levels (i.e., teams) that are created in order to perform a specific process without segmentation.
2. Design is a component of each process, and of each activity, such that the hierarchical structure is compressed by eliminating the hierarchical levels that introduce segmentation, and accordingly delays.
3. Many activities will be performed simultaneously, being the object of the process-team.
4. The response of the enterprise to its external environment is more rapid and consistent to the external requests and expectations.
5. The enterprise is internally and externally oriented to leadership.
6. The quality management will be oriented to TQM (Total Quality Management).

According to the new processes identified as in figure 2, the enterprise will become more flexible and adaptable in satisfying the customers' requests, and also will be able to develop personalized products. Thus, the enterprise will have a larger area of capability in responding to the markets and customers / users.

The new enterprise (i.e., the reengineered enterprise) results as the organizational structure based on the dominant processes and the corresponding process map, as in figures 2 and 3.

In these conditions, the *integrated global quality of the enterprise* can be attained according to the definition of the concept [2]:

Definition 1. The *integrated global quality of the enterprise* represents the assembly of its capabilities that determine an observable, significant and influencing existence of the enterprise in the external environment, such that, through its abilities of technical, economical and financial leadership, and its integration in the society, the dynamics of the enterprise is positively visible in the evolution of the external environment.

Considering the integrated global quality concept it becomes necessary to identify the corresponding approach able to support the selection of the best solution for the enterprise's reengineering.

3. The QFD (Quality Function Deployment) approach in the enterprise's reengineering

Once the decision for reengineering has been made, the re-design of the enterprise develops different reengineering solutions, according to figure 4.

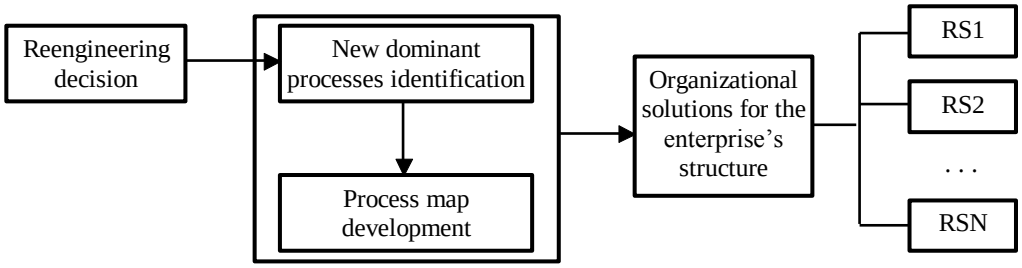

Figure 4. The development of different reengineering solutions for the enterprise.

Thus, the selection of the 'best' reengineering solution becomes a problem for which the QFD (Quality Function Deployment) approach offers the corresponding resolution.

Considering the QFD general theory [3, 4, 5] the approach will be applied to the context presented in figure 4, were the corresponding necessary adaptations will be introduced (see table 1).

Table 1

The QFD approach in the enterprise's reengineering analysis and decision.

1	*The reengineering goals identification and classification*

The main goals that are wished to be attained by the reengineering process will be determined and classified in three types: basically goals (B), performance goals (P), and high performance goals (HP).

For example, these goals may be the following:

G1 – high flexibility of the enterprise;

G2 – fast adaptability to the dynamics of the external environment;

G3 – leadership oriented on the markets;

G4 – high quality of the products

G5 – price competitiveness on the market;

G6 – profit growth;

G7 – good image in the external environment.

Thus, the goals matrix will be developed as in figure 5, with a possible classification.

Goals	**Type**
G1	HP
G2	HP
G3	HP
G4	B
G5	B
G6	P

Figure 5. The reengineering goals identification and classification.

2.	*The goals analysis*

Once the goals identified, they will be analyzed from the following points of view (figure 6):

- the goal importance (L_i) will be determined by evaluating them on a scale from 1 to 10, according to the classification performed at stage 1;
- for each reengineering solution $(S_1, S_2, ...)$ is estimated the level at which each goal is attained, using also a scale from 1 to 10;
- the criticality (K_i) of the goals for the enterprise's policy are identified as following: $K_i = 3$ if the goal G*i* is severely critical; $K_i = 2$ if the goal G*i* is median critical; $K_i = 1$ if the goal G*i* is minimally critical;
- the global weight of each goal will be determined with the relation:

$$w_i = L_i \cdot K_i,\ i = \overline{1,n},\ n = 7; \tag{1}$$

- the relative weight of each goal is determined with the relation:

$$Q_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \cdot 100(\%) \cdot \tag{2}$$

Goal	L_i	S_2	S_1	K_i	w_i	Q_i
G1	10	6	8	3	30	21.43
G2	10	10	10	3	30	21.43
G3	9	5	9	1	9	6.43
G4	9	5	8	3	27	19.28
G5	8	2	10	2	16	11.43
G6	7	6	8	3	21	15.00
G7	7	5	9	1	7	5.00
				TOTAL	140	100

Figure 6. The analysis of the reengineering goals.

3. *The competitiveness characteristics identification*

The set of goals G1 ÷ G7 will be transferred to the corresponding set of characteristics C1 ÷ C12.

Thus, for the considered example the following characteristics will be considered:

C1 – the time of response to the customers' requests;
C2 – the number of markets;
C3 – the average share of the markets;
C4 – the number of independent designs;
C5 – the number of new products;
C6 – the investment level for research in new products;
C7 – the levels of the predicted profits;
C8 – the average risks level of the enterprise's evolution;
C9 – the numbers of customers attached to the enterprise's products;
C10 – the costs with warranties and post-warranty maintenance;
C11 – the number of redesigns in order to make the products competitive;
C12 – the percentage of people that know the name of the enterprise and its products.

4. *The identification of the correlation between the reengineering goals and the competitiveness characteristics and the computation of the characteristics' weights*

The correlation between the reengineering goals *Gi*, $i = \overline{1,n},\ n = 7$ and the identified competitiveness characteristics C*k*, $k = \overline{1,p},\ p = 12$ are determined such that (figure 7): σ represents a strong correlation; μ – a median correlation; ω – a low correlation.

To each type of correlation an non-dimensional measure is considered: $\sigma = 9$, $\mu = 3$, and $\omega = 1$.

Considering the global weight of each reengineering goal, w_i, $i = \overline{1,n},\ n = 7$ determined with relation (1) in figure 6, and the corresponding metrics elements in the correlation matrix (see figure 7), the weight of each competitiveness characteristic C*k*, $k = \overline{1,p},\ p = 12$ will be calculated with the relation (see figure 7):

$$\varepsilon_k = \sum_{i=1}^{n} w_i \cdot g_{ik} \ , \qquad (3)$$

where g_{ik}, $k = \overline{1,p},\ p = 12$ are the values of the correlation metrics of the competitiveness characteristics C*k* for the reengineering goals G*i*.

G/C	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
G1	$\alpha=9$					$\alpha=9$	$\omega=1$	$\mu=3$				
G2	$\alpha=9$	$\mu=3$		$\alpha=9$	$\alpha=9$	$\alpha=9$	$\mu=3$	$\mu=3$				
G3		$\alpha=9$	$\alpha=9$		$\mu=3$	$\alpha=9$		$\mu=3$	$\alpha=9$	$\omega=1$		$\omega=1$
G4	$\alpha=9$	$\mu=3$	$\mu=3$		$\mu=3$				$\alpha=9$	$\alpha=9$	$\alpha=9$	$\omega=1$
G5			$\mu=3$	$\alpha=9$		$\alpha=9$	$\alpha=9$	$\omega=1$	$\mu=3$	$\alpha=9$	$\alpha=9$	
G6		$\alpha=9$	$\alpha=9$	$\mu=3$	$\mu=3$		$\alpha=9$	$\alpha=9$	$\omega=1$	$\alpha=9$	$\mu=3$	
G7	$\mu=3$					$\mu=3$		$\omega=1$	$\alpha=9$	$\mu=3$		$\alpha=9$
ε_k	$\varepsilon_1=$ 804	$\varepsilon_2=$ 441	$\varepsilon_3=$ 399	$\varepsilon_4=$ 477	$\varepsilon_5=$ 441	$\varepsilon_6=$ 786	$\varepsilon_7=$ 453	$\varepsilon_8=$ 419	$\varepsilon_9=$ 456	$\varepsilon_{10}=$ 606	$\varepsilon_{11}=$ 450	$\varepsilon_{12}=$ 99

Figure 7. the correlation matrix between the reengineering goals G*i* and the competitiveness characteristics C*k*. ε_k, $k=\overline{1,12}$ – the weights of the competitiveness characteristics C*k*.

5. *The comparative analysis of the designed reengineering solutions*

Each reengineering solution $(S_1,S_2,...)$ is quantitatively specified at the competitiveness characteristics level, $S_j(C_k)$, $k=\overline{1,p}$, $p=12$, $j=1,2,...$, for this purpose a scale from 1 to 10 being used.

According to the weights of the competitivity characteristics and the solutions' specifications, the global conformity measure for the reengineering solutions, $F(S_j)$, $j=1,2,...$, will be determined with the relation:

$$F(S_j)=\sum_{k=1}^{p}\varepsilon_k\cdot P_{jk}\,, \tag{4}$$

where P_{jk} are the quantitative specifications of the reengineering solution S_j ($j=2$ for the considered example) for the competitiveness characteristics C*k*, $k=\overline{1,p}$, $p=12$.

The results for the considered example are presented in figure 8.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
P_{1k}	7	10	6	8	9	7	10	8	6	5	10	9
P_{2k}	8	5	10	7	10	10	9	5	10	6	10	7
ε_k	804	441	399	477	441	786	453	419	456	606	450	99
$F(S_j)$	$F(S_1)$=44758						$F(S_2)$=47797					

Figure 8. The comparative analysis of the reengineering solutions S_1 and S_2.

The selection criteria of the 'best' reengineering solution in the QFD analysis context is the following:

$$F(S_B)=\max_{j=1,2,...}F(S_j)\,. \tag{5}$$

For the considered example, according to relation (5), the selected reengineering solution is S_2, due to the fact that $F(S_2)>F(S_1)$, $F(S_2)=\max_{j=1,2}F(S_j)$.

4. The Goal-Oriented Framework for Reengineering (GOFR)

In the context determined by the above results, the Goal-Oriented Framework for Reengineering (GOFR) is developed as in figure 9, where the concept of the Life-Cycle of the Reengineered Enterprise (LC-RE) is considered, according to the following definition:

Definition 2. The Life-Cycle of the Reengineered Enterprise (LC-RE) represents the main phases that are performed during the stages of the enterprise's developments determined after the enterprise's reengineering processes.

The main phases of the Life-Cycle of the Reengineered Enterprise (LC-RE) are:

- the enterprise continuous evaluation, analysis, goal identification, and reengineering decision;
- the design of the reengineering solution (QFD analysis included);
- the implementation of the reengineering solution at the level of the organizational structure of the enterprise;
- the continuous improvement of the new (reengineered) enterprise.

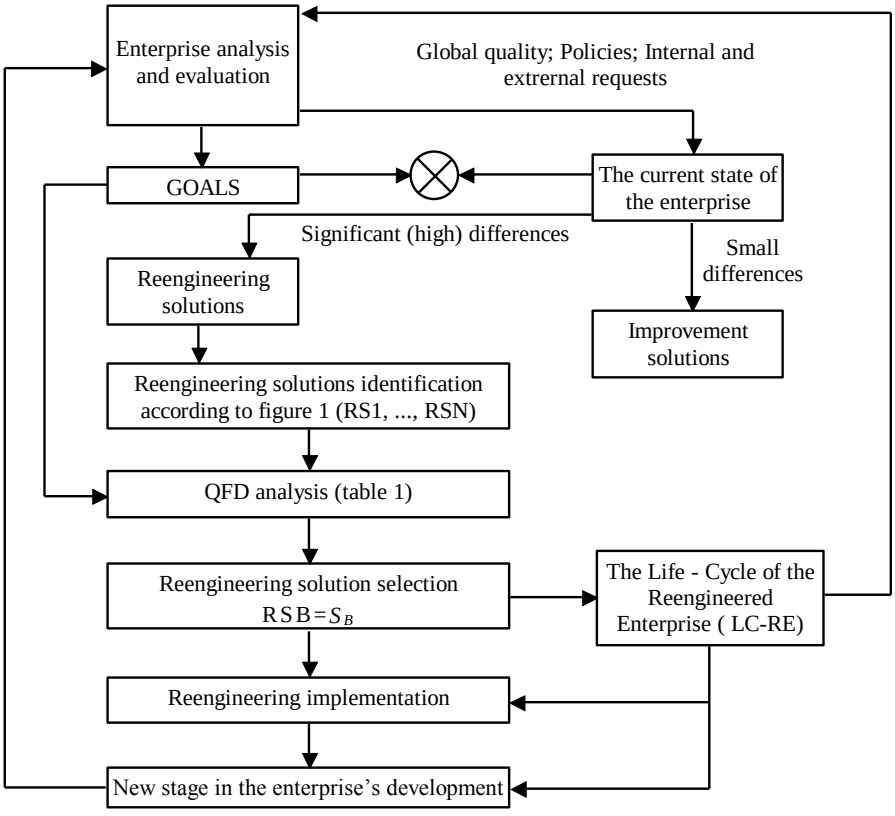

Figure 9. The Goal-Oriented Framework for Reengineering (GOFR).

5. Conclusions

The survival and positive evolution of the enterprise is a major problem in the present complex context of globalisation and multidimensional performance (i.e., technical, economic, financial, social, environmental etc.).

In these conditions, the present paper considers the enterprise's reengineering, and applies the QFD approach for the goal – oriented analysis of the possible reengineering solutions, such that the risks of reengineering are minimized due to the selection of the optimal solution. In this context the concept regarding the global quality of enterprise was introduced as the basis for enterprise's evolution and goals identification. Also, the Goal-Oriented Framework for Reengineering (GOFR) was developed and the Life-Cycle of the Reengineered Enterprise (LC-RE) concept was defined.

The results represent a practical management approach that should be applied in any enterprise in the process of its evolution and continuous development.

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