A Metrics for Evaluation of Environmental Product Development Process

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New products, especially "green" ones, form the focal point for a company's effort in satisfying its custommers' needs. The characteristics, design, styling, reliability, maintainability, reusability, environmentability, convenience for remanufacturing and ranges of the new product – among other things – help the company to gain competitive advantage in meeting customers' needs more effectively than its competitors. New product development (NPD) is a "world" awareness adventure. The importance of NPD process has grown dramatically over the last few decades, and is now the dominant driver in many industries.

Many organizations have realized the need to become more environmentaly responsible or even to become environmentally creative organization. Besides the organization's top management, very important role in acheiving this goal has the **Environmental team** *–* **Eteam**. **Eteam** *shall guarantee that all the activities of the organization will be subjected to analysis with respect to the environmental protection.* **Eteam** *is also responsible and authorized to evaluate the quality of each product life cycle (PLC) phase.*

The definition and establishment of a good quality metrics require the investment of considerable effort and are facing quite a few traps and problems. A metrics need to be established and controlled as a useful job, and it will be useful if it produces useful data and good estimates i.e. if it points at weak places requiring some action. The paper proposes and discusses a group of quality factors according to which the quality of each PLC phase can be evaluated. Those factors represent the highest out of the three-level hierarchical evaluation model. The next, second, level represent transition to phase-oriented quality criteria. The third, lowest, level, is the metrics which quantifies the quality factors. The proposed methodology offers great possibilities for analysis of sensitivity of quality both the PLC phases and of the (complex) product under development with respect to any of quality factors out of the proposed group. The important merit of the proposed three-level metrics also is that it is simple to change and adjust to each specific situation.

Key words: *Product life cycle, Environmental product, Development, Quality, Metrics, Eteam*

1. INTRODUCTION

Fast technology development and increasing products complexity, combined with limited resources, call for implementation of a product development process that is systematic and incorporates high reliability and other quality factors. This imposes new requirements regarding the technological processes of production, operation and maintenance. Besides, modern complex products are often computer&software-based products (CSBP) thanks to fast technological progress in microelectronics and computer techniques. Also we are faced with complex service-based products (SBP), the development of which should follow a systematic approach in compliance with the software engineering requirements [1]. Often, in case of certain particularly complex and highly mechanized SBP´s, there is a high degree of interaction between the hardware, software and the personnel, and in this case an additional analysis should be made defining an optimal approach to the SBP´s development [2]. Investment in the modernization of the product development process always pays back.

The situation with environmental protection we are faced with in the last two decades more and more imposes the consideration regarding ecological requirements in production, and product usage and disposal. The environmental attention has the key aim: to reduce impact of: products´ development processes, products and services on environment.

Only a standardized and to the greatest possible extend disciplined procedure of the product developpment process evaluation may result in a product that will meet all of the specified requirements. In order to achieve this, it is necessary to ensure incorporation of logistics elements and quality characteristics into an Environmental Product Development Process (EPDP). It should be noted here that EPDP logistics elements are closely related to EPDP quality elements. In other words, one may say that, by incorporation of quality elements into the EPDP, logistics elements are also incorporated into the same EPDP to a considerable extent.

In view of these trends, one of the greatest challenges faced by industry, businesses and the general consumers of products and services today is to meet the growing need for more effective and efficient management of all resources during EPDP. The requirement to increase overall productivity in a resource-constrained environment has placed emphasis on all aspects of the development process/product life cycle, and logistics has assumed a major role comparable to research, design, production and product performance during operational use.

For the purpose of an EPDP quality evaluation, it is necessary to introduce a set of basic objects, which describes the key futures of EPDP as well as product

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under development, in each phase of EPDP. Individual object evaluations, taken with certain weight, render a possibility to evaluate the whole EPDP (or the end product). For the purpose of evaluation, this paper proposed minimum of ten basic objects.

The definition of constraints and quality factors for EPDP quality evaluation was initiated based on the following basic requirements for the quality factors and constraints: a factor should enable appreciation of a degree to which different external various parameters influence the EPDP´s quality characteristics; a factor must in its content be as simple as possible, it must be easily measurable and must have low dispersion level, i.e. it should have little dependence on a group of parameters that cannot be controlled; the constraint should take into account the characteristics of the system performance; the constraint should take into account the EPDP´s operational requirements; the constraint should take into account the groundrules.

By groundrules we are referring to information concerning such parameters as the resources available for resolution of problems in EPDP (i.e., necessary manpower skills, computer availability if required, etc.), the time schedule allowed for resolution of the problems and/or related management policy or guidance that will in any way affect the resolution of the problems.

The definition of a certain group of quality factors according to which quality of any object within EPDP would be evaluated was grounded on research works related to development and application of metrics on software quality evaluation [3,4]. The idea developed that the same quality factors according to which software quality evaluation is performed can also serve for quality evaluation of other EPDP basic objects. Of course, the definitions of such quality factors must be as broad as possible.

This paper will propose a group of quality factors according to which the quality of any of EPDP basic objects will be evaluated. Those factors represent the highest level out of the three-level hierarchical model evaluation. The next level is a transition to object-oriented quality criteria whereby the number of criteria determining certain quality factors varies for individual EPDP objects. Certain number of criteria is common to certain factors. The third, lowest, level is metrics which quantifies the quality factors. This paper proposes that, for each quality criterion related to an object, a list be made of detailed proper ties such object should possess in order to achieve certain quality level. The lists proposed are not exclusive but rather render a possibility of their further elaboration (new requirements/issues, quantitative relations...).

2. ENVIRONMENTAL POLICY AND PLANNING

Sustainable production and consumption can only be achieved if all market actors take their own responsibility. The ultimate goal is therefore taking into account environment in every decision making process by industry, retailers and consumers [5].

There are several motivating factors for an organization to become environmental responsible. Some of most notable are [6,7]:

- Legislation.
- Customer demand: Awareness of environmental issues is increasing among customers. Some custommers will even pay more for a product if it is "green". Also, industrial customers do not want (future) environmental liability for a supplier's product.
- Eco-labeling programs: How "green" is a product? Having an eco-label becomes a competitive advantage.
- The following basic environmental management / design standard / guide / directive:
  - 🕮 ISO, ISP/TR 14062, 2002, Environmental management – Integrating environmental aspects into product design and development;
  - 🕮 IEC, Guide 114, 2005, Environmentally conscious design – Integrating environmental aspects into design and development of electro technical products;
  - 🕮 EU, Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005, establishing framework for the setting of ecodesign requirement for energy-using products.

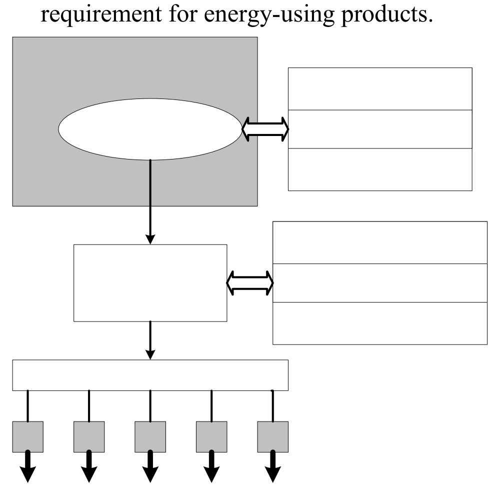

Figure 1 - Environmental management as a part of management of the organization.

Environmental management is a part of organization management. On the Figure 1, the activities of top-level management concerning environment are shown. Considering all aspect that products or production processes may have on the environment, the organization, first of all, must set its *environmental policy* and objectives. *Environmental policy* represents the way the organization behaves in respect to environment and should be in accordance with statutory requirements.

Determined environmental objectives and policy are the basis for environmental management in the organization, and all further activities concerning environment must be set and conveyed in accordance with the organization's environmental objectives and policy.

In order to realize the adopted environmental policy it is necessary that top management assign the ***Environmental team*** (***Eteam***), which is responsible and authorized to ensure that all activities concerning environment are introduced and that they are continuously carried out [6-13].

Eteam, together with all relevant organizational departments of the organization, needs to identify the group of possible pollutants that might be created either during the product use or disposal, or in the production processes, and to direct technical/ /professional interest in the direction of elimination of those pollutants.

Eteam has the responsibility to continuously gather and monitor all information regarding environment, especially for expected pollutants, and to integrate them into existing *Instructions*, which in full details describe, for each organizational entity, work obligations, required equipment and everything else that is necessary to protect environment. This involves all standards, statutory requirements, statutory regulations (discipline actions), as well as the results of scientific and technical researches regarding this area.

The important activity of ***Eteam*** is continuous environmental education and training for the entire organization and according to the adequate programs. Programs must be exactly adjusted to the level and functions of particular groups of employees and must assure the environmental knowledge concerning working activities of those groups. Training must be documented.

On the other side, the responsibility for continuous education must have, for example, design engineers so they could be able, in cooperation with the ***Eteam***, to do product design for environment introducing new materials, new technological processes (cleaner technology) or new methods of pollutants compensation in the design activities.

3. PRODUCT LIFE CYCLE AND A METRICS FOR EVALUATION OF NEW ENVIRONMENTAL PRODUCT DEVELOPMENT PROCESS

3.1. General

New products form the focal point for a company's effort in satisfying its customers' needs. The characteristics, design, styling, reliability, maintainability, reusability, convenience for remanufacturing and ranges of the new product – among other things – help the company to gain competitive advantage in meeting customers' needs more effectively than its competitors.

New product development (NPD) is a "world" awareness adventure. The importance of NPD process has grown dramatically over the last few decades, and is now the dominant driver in many industries. Successful NPD process in a company requires [14-16]:

- minimization of two core factors: time-to-market, and the gap between customer requirements and product characteristics,
- acceptance of eco-efficiency policy (pollution prevention, cleaner technology, design for environment, loop closing, environmental management system – EMS),
- quality evaluation of NDP process.

Also new product must match such customer requirements as new features, superior quality, and attractive pricing.

Eteam shall guarantee that all the activities of the organization will be subjected to analysis with respect to the environmental protection.

Eteam is also responsible and authorized to evaluate the quality of each product life cycle (PLC) phase (*Development and Design*, Introduction, Growth, Maturity, Decline, *Disposal*).

The definition and establishment of a good metrics require the investment of considerable effort and are facing quite a few traps and problems. A metrics need to be established and controlled as a useful job and it will be useful if it produces useful data and good estimates i.e. if it points at weak places requiring some action.

The important merit of the proposed three-level metrics is that it is simple to change and adjust to each specific situation.

3.2. The proposed metrics

During evaluation of the quality of each PLC phase, the phase is at first divided into activities. For each activity of the phase a set of basic objects influencing the activity is defined. The evaluation of the quality of each object is carried out in accordance with a hierarchical model comprising three levels: (i) the highest level consists of quality factors, (ii) the medium level is made of the quality criteria which describe the object properties required for meeting the quality factors, and (iii) the lowest level contains the quality metrics (e.g. requirements, questions, quantitative relations, etc.); it serves for testing the quality criteria in accordance with the quality factor and the relevant object. The metrics gives quantitative evaluations of the quality criteria as the basis for the evaluations of the quality factors and the considered object [17].

Basic quality objects and factors that determine the quality of particular PLC phase could be [17-33]:

- Documentation: usability, correctness, consistency, maintainability;
- Manpower potential (Human resources): effectiveness, reliability, convenience for safe work, flexibility, correctness, usability, maintainability, testability, safety, connectability, acceptability of new knowledge, level of education, ecoconsciousness;
  - Human resources education and training: correctness, reliability, effectiveness, efficiency, usability, flexibility, testability;
  - Hardware (production equipment,…): reliability, effectiveness, usability, reusability, correctness, maintainability, testability, convenience for safety work, flexibility;
  - Dependency from hardware (production equipment, …): conformity with standards, reliability, effectiveness, maintainability, connectability, testability, convenience for safety work, flexibility;
  - Hardware maintenance: maintainability, testability, correctness, reusability, conformity with standards / documentation;

- Software: correctness, reliability, efficiency, usability, reusability, maintainability, testability, flexibility, interoperability;
- Software maintenance: maintainability, testability, correctness, reusability, conformity with standards / documentation;
- Product innovativeness (reliability, feasibility, effectiveness, competitiveness, usability, testability, convenience for evaluations);
- Quality of product (reliability, effectiveness, usability, reusability, extended product responsibility, convenience for remanufacturing, correctness, maintainability, testability, convenience for safety work, flexibility);
- Level of product standardization (usability, transferability, correctness, flexibility, maintainability, testability).

Basic quality factors that determine the quality of:

⇨ the requirements and design life cycle phases could be: ambiguity, completeness, usability, correctness, consistency, volatility, verifiability, ecoconsciousness (how one thinks about the entire ecosystem, including how the eco system is affectted by the life cycle of a product [25]), environmentability, design for recyclability, design for remanufacturing, design for disposability, design for energy recovery;

⇨ the production process could be: usability, correctness, complexity, maintainability, reliability, testability, safety, effectiveness, efficiency, flexibility, convenience for monitoring and controlling, environmentability, process manageability, organizational maturity;

⇨ the quality of use of the product could be: usability, maintainability, reliability, testability, safety, environmentability;

⇨ the product disposal could be: recyclability, convenience for remanufacturing, convenience for decomposing, convenience for disassembling, convenience for incineration.

Examples of quality criteria could be: terminology, structure, resources, consistency, simplicity, conciseness, traceability, adherence to standards, complexity (of design), modularity, complexity (of modules), communication commonality, data commonality, instrumentation, error tolerance, training possibilities.

All estimates obtained at any of the levels could be absolute or corrected by the corresponding weighting factors. The weighting factors represent the relative importance within a considered set; they allow emphasizing certain activities/objects/quality characterristics in conformity with the specific requirements and situation in an enterprise with respect to the product development process. This gives an additional sensitivity to the established metrics.

Let the problem be to determine the quality of a PLC phase P. Let the PLC phase P consists of N activities. Let A^p be a set of activities of PLC phase P (A^p includes the total of N activities):

$$A^p = \{a_1^p, a_2^p, \ldots, a_N^p\}. \tag{1}$$

Let O^p be a set of the basic objects of PLC phase P, containing M members:

$$O^p = \{o_1^p, o_2^p, \ldots, o_M^p\}. \tag{2}$$

Let the weighting factors be defined by a matrix W^p:

$$W^p = [w_{ij}^p],\ i=1,\ldots,N;\ j=1,\ldots,M. \tag{3}$$

In Equation (3) w^p_{ij} is the relative importance of object o^p_j in activity a^p_i of PLC phase P and it applies that:

$$1 \geq w_{ij}^p \geq 0,\quad \sum_{j=1}^{M} w_{ij}^p = 1. \tag{4}$$

It is clear that $w^p_{ij}=0$ if object o^p_j does not have any influence on activity a^p_i of PLC phase P, or if there is any such influence, at the moment of observation (analysis) the relative influence of object o^p_j compared to the influences of other objects on activity a^p_i of PLC phase P is negligible. Also, $w^p_{ij}=1$ if only object o^p_i has the influence on the quality of activity a^p_i of PLC phase P, or if some other objects also have influences on activity a^p_i, but at the moment of observation (analysis) only the relative importance of the influence of object o^p_i, compared to those other objects having influences on activity a^p_i of PLC phase P, is significant.

Let us assume that the estimations of the qualities of basic objects have been carried out in accordance with the proposed three-level hierarchical model: (i) quality factors, (ii) quality criteria, and (iii) quality metrics [6,8] and that the estimates of the qualities of all objects are known.

Let R^p be a set of qualities of the basic objects of PLC phase P:

$$R^p = \{r_1^p, r_2^p, \ldots, r_M^p\}. \tag{5}$$

Let these estimates be normalized so that they represent measures of satisfaction of the requirements set out for the qualities of these objects ($1 \geq r^p_j \geq 0$, j=1, M).

A quality estimate s^p_i of activity a^p_i of PLC phase P ($i = 1,\ldots,N$) is obtained as:

$$s_i^p = \sum_{j=1}^{M} w_{ij}^p r_j^p. \tag{6}$$

The quality estimate, q^p, of PLC phase P is obtained as:

$$q^p = \sum_{i=1}^{N} s_i^p. \tag{7}$$

For obtaining an estimate of the quality of PLC phase P it is possible to introduce a weighting vector V^p, where v^p_i denotes the relative importance of activity a^p_i in PLC phase P ($i = 1,\ldots,N$), where

$$1 \geq v_i^p \geq 0, \quad \sum_{i=1}^{N} v_i^p = 1. \qquad (8)$$

The quality estimate, q^p, of PLC phase P now becomes:

$$q^p = \sum_{i=1}^{N} s_i^p v_i^p . \qquad (9)$$

The quality estimate obtained in this way represents the measure of satisfaction of the quality with respect to the established metrics.

Methodology for EPDP quality evaluation

The methodology for EPDP quality evaluation will further be presented on an example of designing the production process.

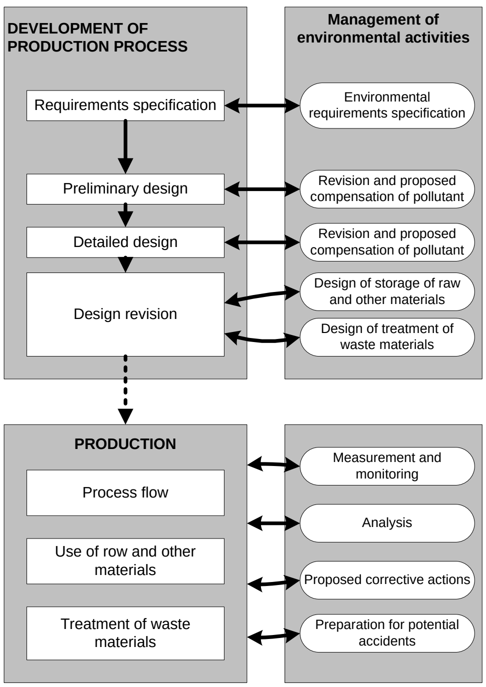

Figure 2 - Activities of environmental management related to the production process

Along with the development or modification of product, development or modification of production process is conducted at the same time. Figure 2 shows environmental management activities in respect to the production process.

Design of the production process is closely related to the design of the product itself, only in this case the activities of environmental protection are related to the organization itself and its surroundings, and not to the use of the product. All the statutory regulations with regard to the ambiance of production halls, such as, for example, maximum allowable temperature, dust concentration in the air, concentration of hazardous particles, concentration of harmful gases, concentration of explosive gases, etc., must be adhered to. The same applies to the statutory regulations with respect to the immediate surroundings of the organization.

If the process is such that it necessarily creates pollutants, it is necessary to right away foresee both the equipment and the procedures to neutralize the pollutants.

The design of the production process, therefore, must be analyzed from the environmental aspect. The procedures related to the designing and commissioning of the production line must, therefore, also include the activities of verification of environmental parameters.

Regarding the quality of designing the production process (PP), first of all, a so called *inclusion matrix* (Table 1) is defined which interconnects the functions performed by PP. The functions are positioned in the upper section of the matrix as F_1, F_2,…, F_N. The basic PP objects (Documentation; Manpower potential; Training of personnel; Process equipment – both hardware and software; Measuring and monitoring devices; Purchasing; Storage; Control – process, product, document, data; Maintenance – both hardware and software; Supporting services – transport, communications…; Improvement of PP…) are positioned on the left-hand side of the matrix as BO_1, BO_2,...BO_M. The term "inclusion matrix" implies that the information this matrix contains talks about the actual basic PP objects necessary for performance of certain PP functions. Asterisks (★) on the matrix indicate existence of relation between the observed function performed by way of PP and the basic PP object in question. This matrix is important because, based on it, certain conclusions can be brought with respect to relative significance of individual PP basic objects in performance of the specified functions.

Table 1 - The Inclusion Matrix

Basic PP objects	Functions				
	F_1	F_2			F_N
BO_1	★				★
BO_2	★	★			★
BO_M	★	★			

Relative significance of certain basic PP objects is obtained in the following way. Each of the specified functions implemented by way of PP is dedicated certain weight w (e.g. from 1 to 10, as in this case). Now each asterisk in each function column of the Inclusion Matrix (Table 1) is replaced by the corresponding function weight to which the column pertains. Thus a transition is made from the *Inclusion Matrix* to the so-called *Matrix of Relative Significance of Basic PP Objects* (Table 2).

Table 2 - Matrix of Relative Significance of PP Objects

Basic PP objects	F	F_1	F_2			F_N	3	No
	w_{fi}	8	10			6		
BO_1		8				6		N-1
BO_2		8	10			6		1
BO_M		8	10					3

3 symbol in this matrix signifies a functional value of relevant basic PP object expressed through a number of scores obtained as a sum of weights for the corresponding type of matrix. Based on the values in column *3* the column *No* is filled in which determines the rank of the basic PP objects. This rank is prevailing in assignment of weights to individual basic PP objects.

The relationship between main PP characteristics and the proposed quality factors of one real PP is presented in Table 3.

Based on Table 3, the following basic group of PP quality factors was established: reliability, testability, maintainability, flexibility, portability, efficiency, integrity and interoperability.

Table 3 - Basic futures of PP

FEATURES OF A REAL PRODUCTION PROCESS	QUALITY FACTOR
PP failure jeopardizes the PP itself as well PP depending on it	Reliability Correctness Testability
Long operational life exposed to changes of hardware technology	Maintainability Flexibility Portability
Interactive operation in time-sharing mode of computer resources	Efficiency Reliability Correctness
Requirement for integrity of information processed in the system	Integrity
System is interfaced with other systems	Interoperability

The next step is to find relationship between the proposed quality factors for each basic object out of the group of basic PP objects.

Relationships between quality factors for the basic PP objects are elaborated in the form of *triangular matrices* indicating the degree of quality (high, low or absence of any relationship) that is expected from other quality factors if high quality of the observed quality factor is achieved.

Based on such matrices, which should be elaborated in detail during a real PP evaluation, for each of PP objects conflicting situations are determined between individual quality factors. Those quality factors that are found in such conflicting situations most often are then taken either with a lower weight when evaluating quality of an observed object or they are completely excluded from such evaluation. Taking into account such conflicting situations one arrives at the basic core of important quality factors for each of the basic PP objects which, in quality evaluation of certain objects, should be assigned the greatest weight.

The quality of each that discussed PP objects can be defined as a group of properties the enable performance of functions implemented by that particular object.

Object quality evaluation is performed according to the described three-level hierarchical model. Quality factors pertain to the highest level.

The next level in definition of requirements with respect to the quality of individual PP objects represents the transition from quality factors to object-oriented quality criteria. A group of quality criteria representing certain object features is brought into a relationship with the proposed group of quality factors through definitions of those factors. Identification of quality criteria is almost automatic whereas the criteria themselves represent detailed specification of requirements with respect to the quality of the PP object in question.

The third, lowest, level within the model for quality evaluation of various PP objects is metrics. Metrics should quantify the quality factors. According to the state of the art in system and software engineering, there are no unanimously adopted measures for evaluation of individual objects of technical and information system. Therefore, the following approach is proposed. For each criterion of a quality factor a list should be made specifying detailed features-in the form of questions-which that object should possess in order to have certain quality level. The lists proposed are by no means exclusive: They render a possibility of their completion, setting of new requirements/questions, quantitative relations and the like. It should be mentioned here that the lists for quantification of the same quality criteria generally differ depending on which quality factors they pertain to.

Example

PP in an organization was evaluated for modernization purposes. As an example, evaluation was efectted with respect to the basic object: Manpower Potential for the PP (Figure 3). Based on the individual evaluations of quality factors and detailed insight into the relevant metrics, certain requirements were made with respect to modernization of the basic object Manpower Potential the implementation of which is expected to provide improved quality of that basic object.

System: PP in an organization
Basic Object of PP: BO_2
Rating: POOR (0.29)

QF1 - Correctness, QF2 - Reliability, QF3 - Efficiency, QF4 - Usability, QF5 - Flexibility, QF6 - Testability, QF7 - Maintainability

Figure 3 - Results of evaluation of quality factors for the basic object: Manpower potential of a PP.

ACTIVITIES OF THE *ETEAM*

The activities and responsibilities of the members of ***Eteam*** can be classified into two groups. On the one hand, they are targeted on incorporation of environmental requirements in the processes of design, production, use and disposal of products, and on the other, they are directed towards the monitoring of the achieved results, i.e. towards the monitoring of pollution. The set of the activities of the ***Eteam*** consists of:

1. Familiarization with the prevailing statutory and technical regulations and standards from the field of environment, and monitoring of all changes in that area. Initiation of quality metrics (QM) program.
2. Analysis of the requirements for a product and production process (modification or upgrading). Analysis of the requirements for storage of raw materials and treatment of waste materials.
3. Design revision in the course of designing (together with the experts involved in the product development). Thereby it is monitored whether all the elements of environmental protection are incorporated into the product and the production process.
4. Elaboration of instructions for use and disposal of the product (together with the product designers).
5. Monitoring of the parameters of pollution of the organization and its surroundings. This includes not only measurements and making of reports, but also the procurement and maintenance of measuring equipment, production of wind rose, monitoring of meteorological conditions, follow-up of the health status of the employees and of the population in the surroundings, etc.
6. Monitoring of all available data related to the use of the product and making of relevant reports.
7. Analysis of periodic reports and establishing whether the environmental goal has been achieved: whether a product has been made whose use and disposal shall not cause degradation of the environment and whether the interior of the organization and its surroundings satisfy the environmental requirements. The results of the analysis are presented to the top management of the organization. If everything is favorable, the activity loop goes back to the activity (v), i.e. the parameters of pollution are further monitored. If the results of the analysis are not satisfactory, it is necessary to undertake corrective actions.
8. Corrective actions can be related to all the activities within the life cycle of the product. That is why cooperation between all the relevant participants is required in the processes of design, production, procurement of raw and other materials, storage, etc., in order to satisfy the environmental requirements with the new solutions.

5. SUMMARY

The creation of new products especially "green" ones is not easy, and most likely will never be. People involved in the creation of new products must look at markets, customers, distribution channels, marketing techniques, technology strategy, eco-efficiency, organizational context within which a product development project is embedded, product development project teams, tools to improve the efficacy of product development process, finances, government regulations, forming standards, following standards, and so on.

The methodology presented in this paper has primarily been conceived and elaborated for the purpose of quality evaluation of Environmental Product Development Process. It is, however, sufficiently broad to provide for evaluation of the majority of complex systems. The proposed metrics can easily be extended and changed to include the latest knowledge of the systems the quality of which should be evaluated.

Many organizations have realized the need to become more environmentaly responsible or even to become environmentally creative organization. Besides the organization's top management, very important role in acheiving this goal has the ***Environmental team*** – ***Eteam***.

Eteam shall guarantee that all the activities of the organization will be subjected to analysis with respect to the environmental protection.

Eteam is also responsible and authorized to *evaluate the quality* of each product life cycle (PLC) phase.

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REZIME

METRIKA ZA OCENJIVANJE PROCESA RAZVOJA EKOLOŠKIH PROIZVODA

Novi proizvodi, posebno oni "zeleni", predstavljaju žižu napora bilo koje kompanije u zadovoljavanju potreba kupaca. Karakteristike, dizajn, oblikovanje, pouzdanost, pogodnost za održavanje, pogodnost za ponovno korišćenje, usaglašenost sa ekološkim zahtevima, pogodnost za ponovnu proizvodnju i raznovrsnost varijanti novog proizvoda – između ostalog – pomažu kompaniji da stekne konkurentsku prednost u zadovoljavanju potreba kupaca efektifnije od svojih konkurenata. Razvoj novog proizvoda (RNP) predstavlja "svetsku" svesnu avanturu. Značaj RNP procesa je dramatično je porastao u poslednjih nekoliko decenija, i danas je dominantan pokretač razvoja u mnogim industrijama.

Mnoge organizacije su shvatile potrebu da postanu odgovornije u pogledu ekologije ili čak da postanu ekološki kreativne organizacije. Osim top menadžmenta organizacije, vrlo važnu ulogu u ostvarenju tog cilja ima ***Ekološki tim*** *–* ***Etim***. ***Etim*** *treba da garantuje da će sve aktivnosti organizacije biti podvrgnute analizi u pogledu ekološke zaštite.* ***Etim*** *je takođe odgovoran i autorizovan da oceni kvalitet svake faze životnog veka proizvoda (ŽVP).*

Definisanje i uspostavljanje dobre metrike kvaliteta zahteva ulaganje značajnog truda i suočava se sa nekoliko zamki i problema. Metrka treba da bude uspostavljena i korišćena kao korisna aktivnost, a biće korisna ukoliko ako da korisne podatke i dobre procene, tj. ako ukaže na slabe tačke koje zahtevaju određenu intervenciju. U radu se predlaže i razmatra grupa faktora kvaliteta u odnosu na koje može da se oceni kvalitet svake ŽVP faze. Ovi faktori predstavljaju najviši nivo tonivoskog modela za ocenjivanje. Sledeći, drugi, nivo predstavlja prelazak na kriterijume kvaliteta orijentisane na konkretnu fazu. Treći, najniži, nivo je metrika koja kvantifikuje faktore kvaliteta. Predložena metodologija nudi velike mogućnosti za analizu osetljivosti kako ŽVP faze tako i (kompleksnog) proizvoda koji se razvija s obzirom na bilo koji od faktora kvaliteta iz predložene grupe. Važno svojstvo predložene tronivoske metrike je i jednostavna promena i podešavanje prema svakoj specifičnoj situaciji.

Ključne reči: *životni vek proizvoda, ekološki proizvod, razvoj, kvalitet, metrika, etim*