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QUALITY MANAGEMENT SYSTEM MODELLING OF VEHICLE INSPECTION STATIONS

Summary. The subject of the article is problems of quality assurance modelling at the Vehicle Inspection Stations (SKP). The essence of the quality management and assurance at the SKP has been presented as well as their influence on efficiency and effectiveness of SKP activities, to meet the clients' quality requirements. Two models were described: process and neural quality assurance at the SKP.

MODELOWANIE SYSTEMU ZARZĄDZANIA JAKOŚCIĄ STACJI KONTROLI POJAZDÓW

Streszczenie. Przedmiotem artykułu są zagadnienia modelowania zapewnienia jakości Stacji Kontroli Pojazdów (SKP). Przedstawiono istotę zarządzania jakością oraz zapewnienia jakości SKP oraz jej wpływ na skuteczność i efektywność działania SKP, a tym samym na spełnienie wymagań jakościowych klientów. Scharakteryzowano modele: procesowe i neuronowe zapewnienia jakości SKP.

1. INTRODUCTION

The interest in the subject of quality management has grown lately among the Vehicle Inspection Stations. The successful organizations on the market have quality management systems introduced according to the international standards [2,4]. Thus they have the elements of planning, realizing and monitoring processes taking place in the firm, in their procedures for activities.

Increased interest in the implementation of the quality system solutions is brought about by publishing of the report by Supreme Chamber of Control, entitled „Information about the results of the inspection of conducting supervision by Regional Administration over Vehicle Inspection Stations, permitting motor vehicles to be used on the roads" from April 2009.

This report contains, a number of allegations concerning reliability and credibility of the tests conducted by the Vehicle Inspection Stations, insufficient qualifications of the diagnostic personnel, and insufficient supervision over those institutions. Detailed analysis of the quoted report can be a material of the separate paper. The authors would like to draw attention to the main issue contained in the report, unequivocally indicating the system shortcomings. It is worth stressing that an official activity conducted by the Vehicle Inspection Stations, is regulated by law. For example, the price list for the technical inspections, is set by the Minister of Infrastructure's Directive. That means, that in

the free market economy, the Vehicle Inspection Stations cannot compete with each other with the height of the fees for the inspections. Hence the essential question, from a business point of view, how then to draw in clients, without lowering the quality of the vehicle technical inspections, at the same time? It is important to note three main aspects of this problem:

- competent personnel,
- measuring and testing equipment,
- technology of conducting technical inspections.

Interlinking these elements constitutes the quality management system at SKP. Unknown is however, its current level and degree of complication. It will be different for independent facilities having endorsements as Vehicle Inspection Stations, and different for Vehicle Inspection Stations, which are only a sectioned off part of larger organisations. Other problems will take place in such facilities in villages and small towns, and another in larger agglomerations. Having earlier mentioned the SKP equipment, it is worth to note, that a modern equipment of the facility does not necessarily guarantee the high quality of the vehicle technical inspections. For example, for propaganda reasons, there are often used phrases containing word "computer", like „computer register", „computer vehicle geometry tests" etc. supposedly being synonymous with the high quality. The consumers have to however remember, that the computer is only a tool. Having even the best equipment, it cannot be used without a sufficient knowledge, experience or ability. How then to achieve a higher quality of the vehicle technical inspections at the Vehicle Inspection Stations? In the authors' view, it is essential to build the theoretical model of the vehicle inspection stations' quality management system, bearing in mind their different specifics, and then have it subjected to exemplification, such as using artificial neural networks. Only in a situation, when we are able, objectively and effectively conduct analysis using proposed model, it will be possible to form effective measures to improve vehicle technical inspections. The analysis of the authors' practical experiences led to an observation, that from the methodological point of view, artificial neural networks can successfully support decision making processes in the quality assurance at the Vehicle Inspection Stations, preventing such pathological cases as mentioned in the NIK report.

2. SKP QUALITY MANAGEMENT

According to [1], the SKP quality management encompasses several elements: establishing quality policy and quality goals, quality planning, quality governing, quality assurance and quality improvement (Fig. 1).

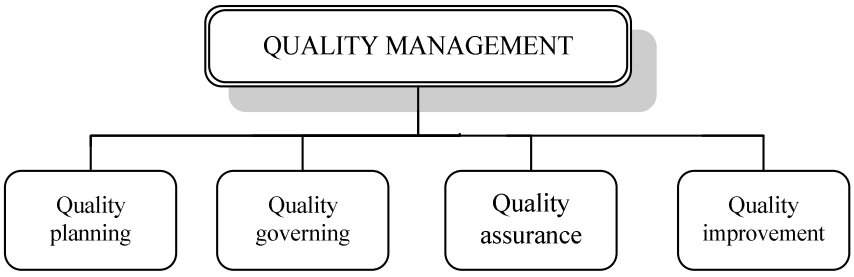

Fig. 1. The essence of the quality management
Rys. 1. Istota zarządzania jakością

Quality planning is directed at establishing quality goals (i.e. „the subjects of the attempts or intentions as far as the quality is concerned" [1]) and is used by the SKP to plan processes, which will enable to achieve the envisaged goals, both those external as well as internal. Those first ones, linked with the client's satisfaction, are product oriented. The others, linked with the SKP organization, refer to improving the organization itself and the processes taking place there. It is essential to allocate the same priorities to the quality goals as to those organizational of financial ones. Quality planning may be treated as an active entering into the entire quality management process. Correct activities towards planning serve to reduce the necessities of improving the system at the later date, thanks to the

satisfactory implementation of the plan in a first place. Quality control is directed at meeting the client's quality requirements, while the quality assurance – at ensuring trust, that those requirements will be met. Quality improvement is a „part of quality management directed at increasing the ability to meet the quality requirements" [1].

Quality assurance[1] is directed at creating confidence by the SKP that the client's quality requirements for the services provided, will be complied with. This could be helped by methods and tools, whose examples are presented in the Fig. 2.

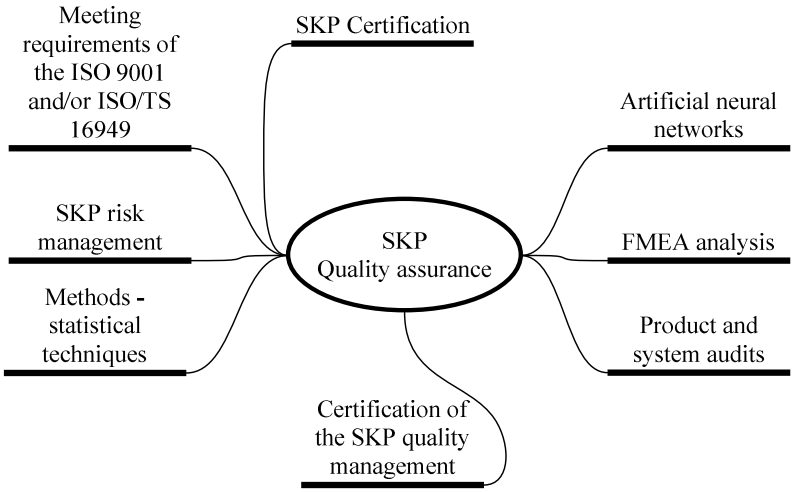

Fig. 2. SKP Quality assurance model
Rys. 2. Model zapewnienia jakości SKP

3.SKP QUALITY MANAGEMENT SYSTEM MODELLING

The essence of approaching the quality management system is a process approach (Fig. 3).

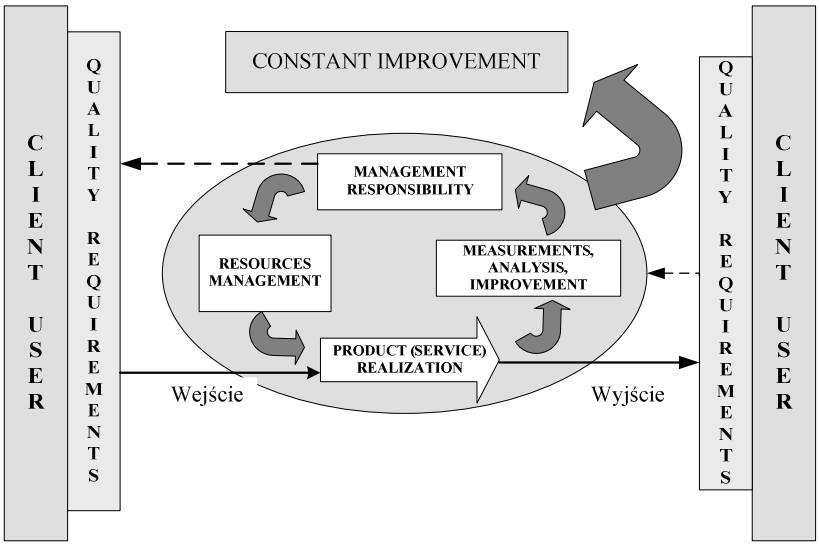

Fig. 3. Process model of the quality management system
Rys. 3. Procesowy model systemu zarządzania jakością

[1] Quality assurance – part of the quality management directed at ensuring confidence that the quality requirements will be met. Quality management – coordinated activities referring to managing the organisation and its supervision as far as quality is concerned [1].

Fig. 4 shows (based on [2]) the requirements of the ISO 9001:2008 international standard, which is a basis for the quality management system requirements in each organisation, including also SKP.

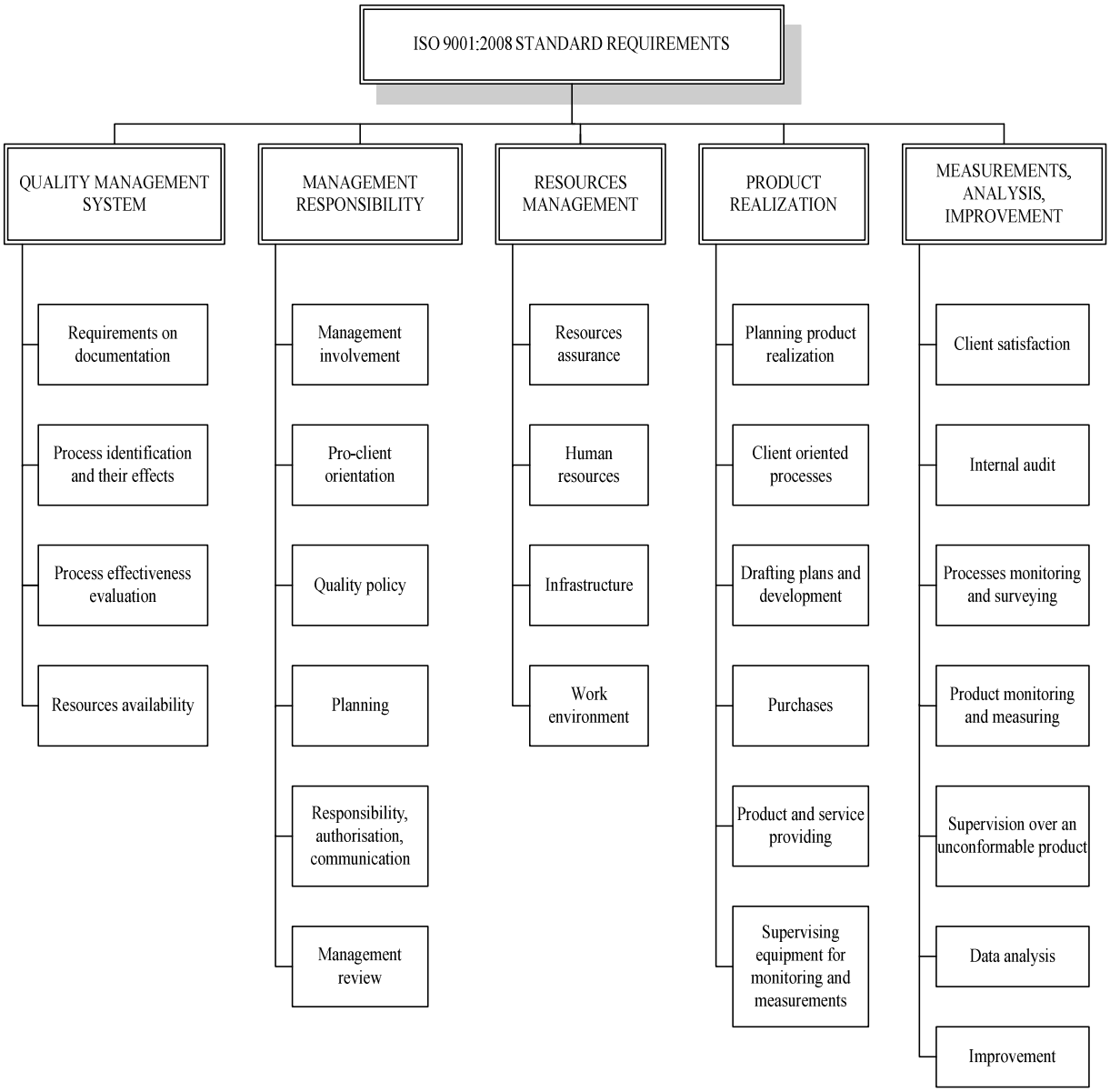

Fig. 4. ISO 9001:2008 standard requirements
Rys. 4. Wymagania normy ISO 9001:2008

In the SKP quality management, an essential role is played by compliance with the requirements [2, 4] as well as an assessment of the compliance, conducted by independent certifying bodies in the certification processes[2].

The Fig. 5 shows an example of requirements [2] concerning providing a service by the SKP.

[2] Certification – the procedure, as a result of which, the third party provides a written assurance, that the product, process or a service are compatible with the specified requirements [3].

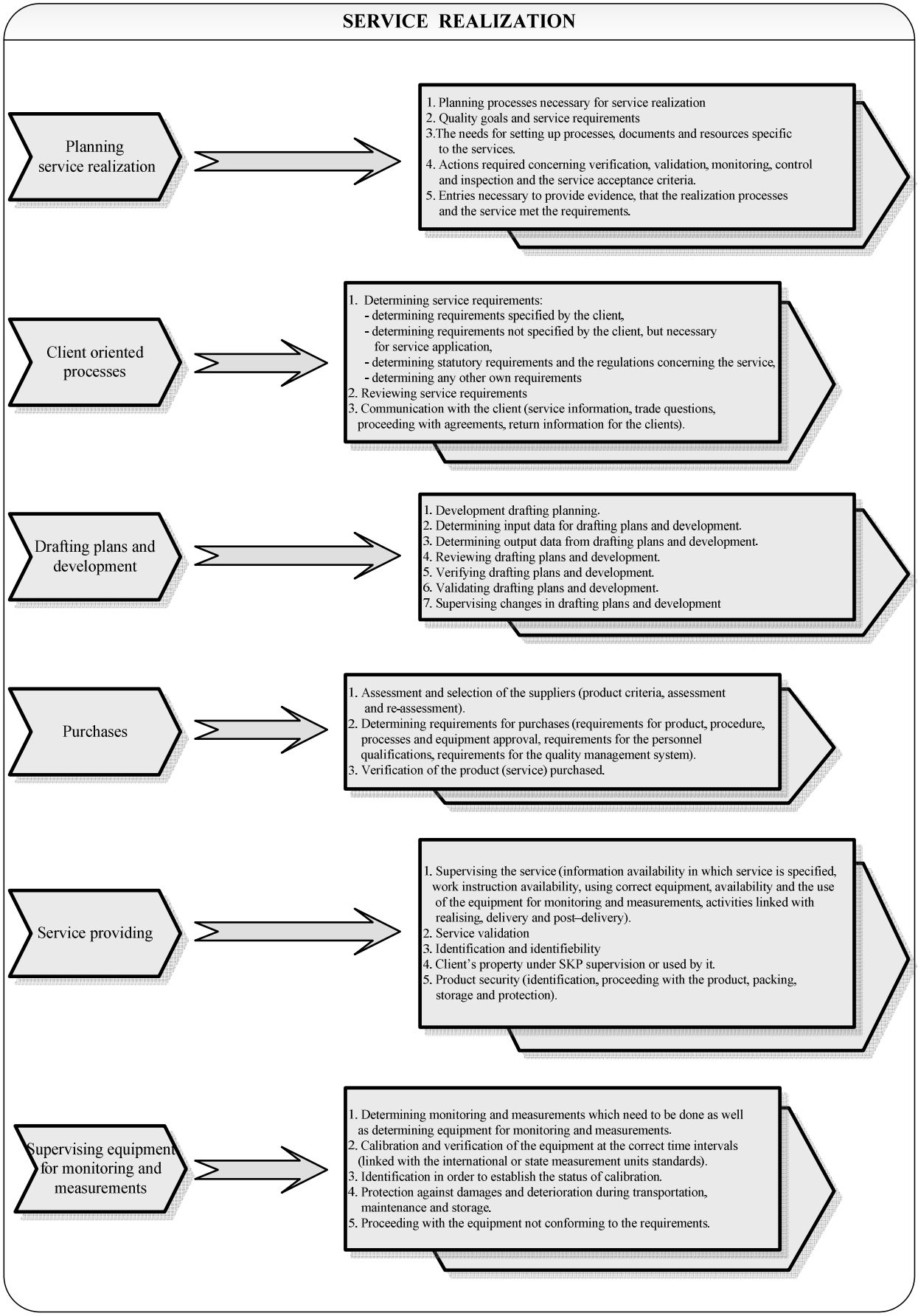

Fig. 5. Selected quality management requirements concerning service realization at the SKP
Rys. 5. Wybrane wymagania zarządzania jakością w zakresie realizacji usługi w SKP

During realization of the processes it is essential to monitor them consistently, in order to ensure their effectiveness. This approach provides the possibility to respond immediately in case, the weak points of the process, are detected. However, only constant improvement of the processes leads to eradicating such points.

Each, above mentioned, requirement presented in the process model can be parameterized during the expert assessment. Parameterized marks can serve to create SKP quality management system neural model (Fig. 6).

Fig. 6. SKP quality management system neural model
Rys. 6. Neuronowy model systemu zarządzania jakością w SKP

This model can be portrayed as function $A(t)$:

$$A(t) = f\left(\alpha_1(t), \alpha_2(t), ..., \alpha_{k-1}(t), \alpha_k(t)\right) \tag{1}$$

where: $A(t)$ - function of the SKP quality management system assessment conducted during time t, $\alpha_k(t)$ - evaluation of the k-tieth requirement of the ISO9001:2008 standard conducted during time t

Artificial intelligence techniques, including artificial neural networks (SSN), are widely described in the literature, but not in the aspect of SKP quality management. The authors used them for the quality management (mainly in the certification processes) to evaluate the SKP's compliance with particular requirements. The models based on SSN can successfully be used in the SKP certification (Fig. 7) [13]. The use of SSN serves mainly as a support for making correct decisions by the managers of the certifying bodies during the certification processes and by SKP management to assess efficiency of SKP quality management system functioning as well as in the business decision making processes.

The same SSN can also be used to verify the experts' work, who conducts the SKP quality management systems evaluation.

The authors based their practical SKP quality management system modelling and assessment of its condition as well as calculations, on the computer programs using SSN: JETNET 2.0 developed in the FORTRAN 77 and STATISTICA 7.1 languages [7]. Program JETNET 2.0 utilises algorithm of the momentary method of backward error propagation [10], STATISTICA 7.1 - other methods for teaching the network, such as: Levenberg-Marquardt, Quasi-Newton coupled gradients. Majority of them, have been tested by the authors during modelling and searching for the best SSN structure, which they proposed for practical use.

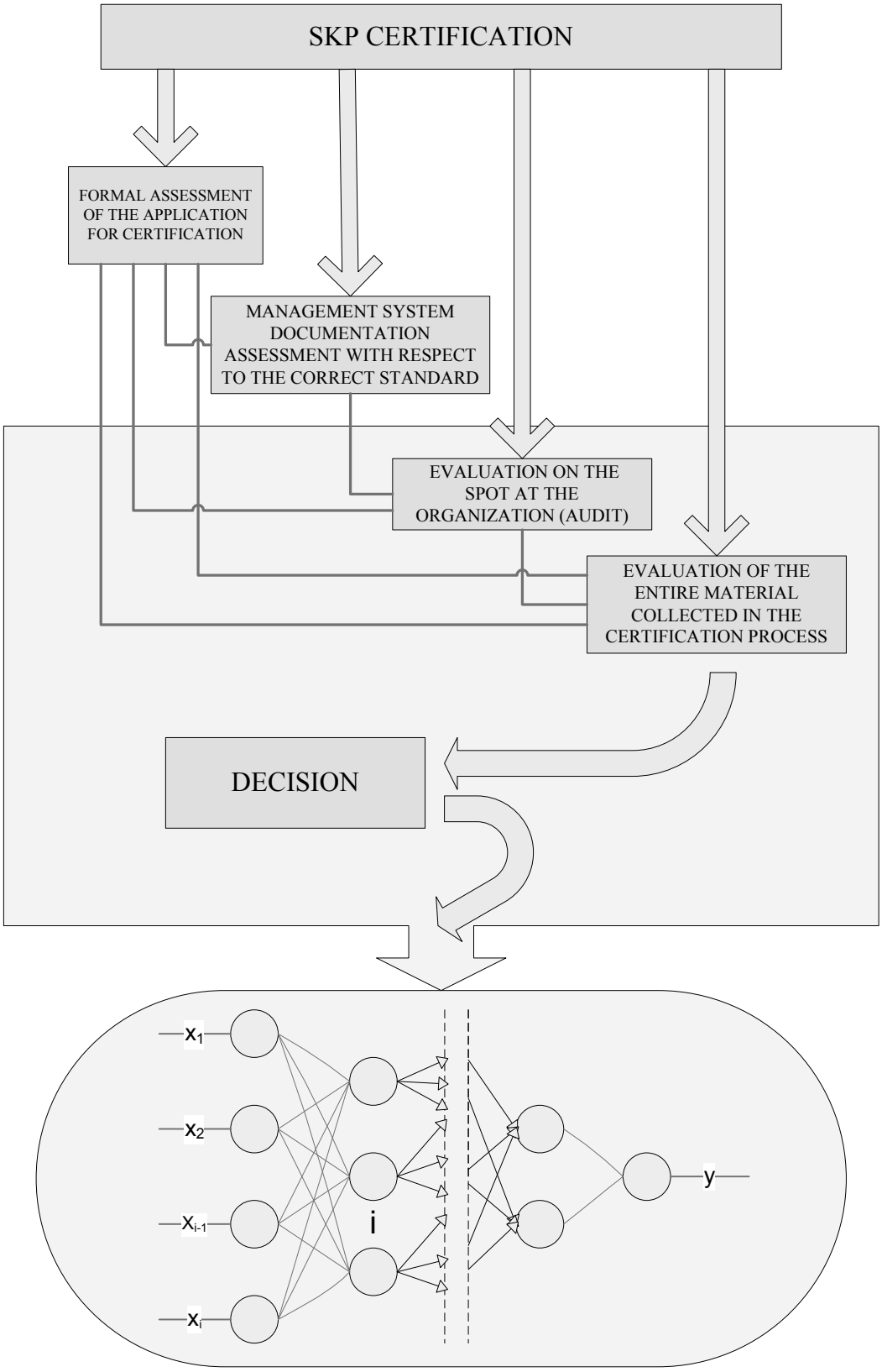

Fig. 7. Decision making neural model in certification
Rys. 7.Neuronowy model podejmowania decyzji w certyfikacji

To teach the network under supervision [10], the results of the audits obtained by the auditors (experts) from Quality Systems and Management Department of the Ministry of Defence, have been

used. The input signals of the $\alpha_k(t)$ model constitute expert assessments of the compliance with the each requirement of the ISO 9001:2008 standard during time t, presented in the scale: 0 – 0,25 – 0,50 - 0,75 – 1. The output signal constitutes general expert assessment of the quality management system functioning, presented in the scale [0 - 1].

Wanting to use SSN to support the decision making in the SKP quality management system certification processes, several problems needed solving:

- collect data, mainly from the audits, concerning compliance, with the ISO 9001:2008 standard requirements, by the organizations,
- appropriately systematize parameterised data,
- planning to use suitable computer program to create a mathematical model,
- planning of the SSN structure,
- teach SSN relying on the data introduced,
- test SSN and draw conclusions.

Algorithm of building and using SSN is presented on the Fig. 8.

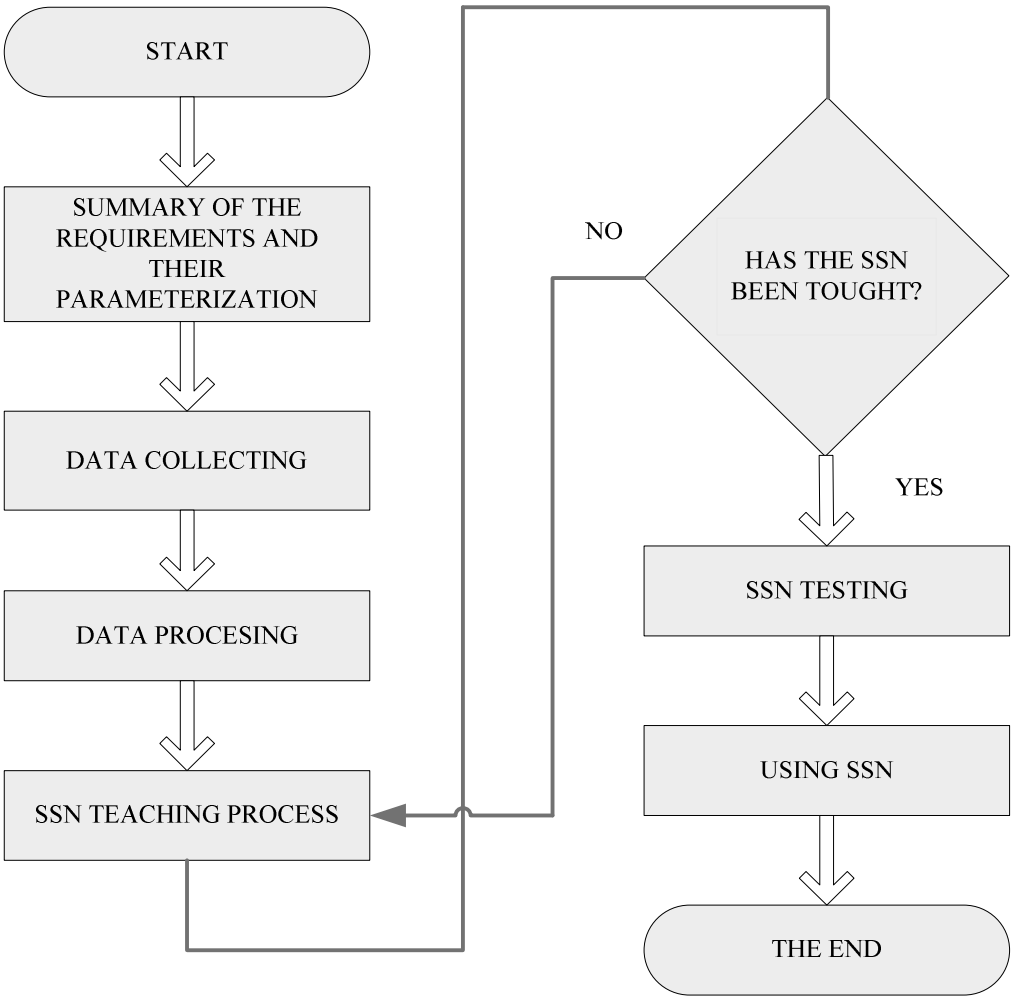

Fig. 8. SSN building algorithm
Rys. 8.Algorytm budowania SSN

During modelling and determining SSN structure, various values have been used for the: momentum coefficient, teaching coefficient, number of the hidden layers and the number of neurons in these layers. Also, the behaviour of the network has been tested, using various computer programs.

In order to determine mathematical models of conducting the assessment, (quality management system functioning) the unidirectional and multilayered line networks, have been used.

The Tab. 1 presents the examples of selected calculations' results, using JETNET 2.0 program, the influence of the teaching coefficient η and momentum coefficient α on the network teaching process for $n=10^6$ iterations.

Tab. 1

The influence of the teaching coefficient and momentum coefficient on the network teaching process for $n=10^6$ iterations

η α	Network structure (number of neurons in the layers)					% of the positive occurrences	$\chi^2_{śr}10^2$
	WE	Hidden layers			WY		
0,05 0,5	21	15	10	5	1	100	0,04
0,05 0,8	21	15	10	5	1	95	0,28
0,05 0,6	21	15	8	-	1	100	0,04
0,05 0,6	21	10	-	-	1	95	0,34

The data from the 20% of audits have been used for the network testing, which were not taken into account during the network teaching. In each case of the neural networks mentioned in the Table 1, the parameter $\chi^2_{śr}$, associated with the testing error was similar to the same parameter associated with the teaching error.

4. SUMMARY

There could be several conclusions drawn from the authors' deliberations:

- The concept of using modelling, both process and neural, is justified and makes sense for the efficiency and effectiveness of the SKP activities.
- Process model of the quality management system causes, the correct identification, understanding and managing of the interconnected processes, to contribute to increasing efficiency and effectiveness of the SKP activities.
- The sources [11, 12, 13] indicate, that it is possible to use neural model to support the decision making process in the SKP quality management system certification.

The article's intention is to signal an introduction of the mathematical modelling methods of the SKP quality management system to evaluate the quality of the services provided by them. The results of the investigations undertaken will successively be presented in the subsequent publications.

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