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AUTOMATION OF SCIENTIFIC AND ENGINEERING COMPUTATIONS WITH EVEREST PLATFORM

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Abstract: *The complexity of high-performance computing infrastructures and applications require the use of problem-oriented interfaces and automation of basic activities in order to support the solving of complex scientific and engineering problems. The use of service-oriented approach and cloud computing models can improve the research productivity by enabling publication and reuse of computing applications, as well as creation of cloud services for automation of computations. The paper describes the implementation of this approach in the form of a web-based platform following the Platform as a Service model. Unlike other solutions, the presented Everest platform runs applications on external computing resources connected by users, implements flexible binding of resources to applications and provides an open programming interface.*
KEYWORDS*: RESEARCH AUTOMATION, CLOUD, SERVICES, DISTRIBUTED COMPUTING, WORKFLOW, PARAMETER SWEEP*

1. *Introduction*

Computational methods and high-performance computing resources are now widely used for solving complex scientific and engineering problems. However, the inherent complexity of corresponding software and infrastructures, along with the lack of required IT expertise among the researchers, require the use of problem-oriented interfaces and automation of basic activities in order to support the process of problem solving. The examples of such activities include running computing applications on HPC resources, integration of multiple computing resources, sharing of computing applications, combined use of multiple applications and running parameter sweep experiments.

The use of service-oriented approach and cloud computing models can improve the research productivity by enabling publication and reuse of computing applications, as well as creation of cloud services for automation of the mentioned activities [1]. The paper describes the implementation of this approach in the form of a web-based platform following the Platform as a Service model. The implementation of the platform and its use for automation of computing activities are discussed.

2. *Everest Platform*

Everest [2] is a web-based distributed computing platform. It provides users with tools to quickly publish and share computing applications as services. The platform also manages execution of applications on external computing resources attached by users. In contrast to traditional distributed computing platforms, Everest implements the Platform as a Service (PaaS) model by providing its functionality via remote web and programming interfaces. A single instance of the platform can be accessed by many users in order to create, run and share applications with each other. The platform is publicly available online to interested users [3].

A high-level overview of Everest architecture is presented in Figure 1. The server-side part of the platform is composed of three main layers: REST API, Applications layer and Compute layer. The client-side part includes the web user interface (Web UI) and client libraries.

Applications are the core entities in Everest that represent reusable computational units that follow a well-defined model. An application has a number of *inputs* that constitute a valid request to the application and a number of *outputs* that constitute a result of computation corresponding to some request. Upon each request Everest creates a new *job* consisting of one or more computational *tasks* generated by the application according to the job inputs. The tasks are executed by the platform on computing resources specified by a user. The dependencies between tasks are currently managed internally by applications. The results of completed tasks are passed back to the application and are used to produce job outputs or new tasks if needed. The job is completed when there are no incomplete tasks are left. The described model is generic enough to support a wide range of computing applications.

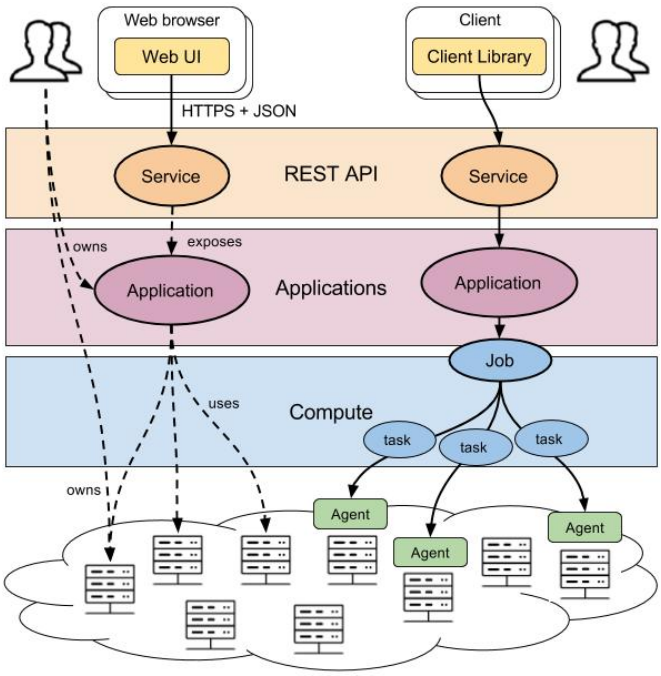

Fig. 1 *Everest Architecture.*

Users can publish applications via provided generic application template that makes it possible to avoid programming. The template supports running arbitrary applications with command-line interface and produces a single task corresponding to a single command run. Recent developments made it possible to dynamically add new tasks or invoke other applications from a running application via the Everest API. This enabled users to create and publish complex many-task applications with dependencies between tasks, such as workflows. Everest also provides a built-in generic application for running parameter sweep experiments consisting of a large number of independent compute tasks discussed in Section 3.

An application is automatically published as a RESTful web service with a unified interface. This enables programmatic access to applications, integration with third-party tools and composition of applications into workflows as discussed in Section 3. The platform's web user interface also generates a web form for running the application via web browser. While existing computational portals implement similar interfaces, typically only portal administrators can add new applications or resources to the system. In contrast, Everest enables users to add new applications by themselves and manage them via convenient web interface. This

approach helps to engage researchers in sharing applications with each other. The application owner can manage the list of users that are allowed to run the application.

Instead of using a dedicated computing infrastructure, Everest performs execution of application tasks on external resources attached by users. The platform implements integration with standalone machines and clusters through a developed program called *agent*. The agent runs on the resource and acts as a mediator between it and Everest enabling the platform to submit and manage computations on the resource. Everest also supports integration with other types of resources, such as grid infrastructures.

Everest users can flexibly bind the attached resources to applications. In particular, a user can specify multiple resources for running an application, thus seamlessly combining these resources into a single computing pool [4]. Everest manages execution of tasks on remote resources and performs routine actions related to staging of input files, submitting a task, monitoring a task state and downloading task results. The platform also monitors the state of resources and uses this information during scheduling.

3. Automation of Many-Task Computations

Automation and application composition via Everest API

Running Everest applications via the platform's web interface is easy and convenient, but it has some limitations. For example, if a user wants to run an application many times with different inputs, it is inconvenient to submit many jobs manually via a web form. In other case, if a user wants to produce some result by using multiple applications, she has to manually copy data between several jobs. Finally, the web interface is not suitable if one wants to run an application from his program or some other external application.

To support all these cases, from automation of repetitive tasks to application composition and integration, Everest implements a REST API. It can be used to access Everest applications from any programming language that can speak HTTP protocol and parse JSON format. However REST API is too low level for most of users, so it is convenient to have ready-to-use client libraries built on top of it. For this purpose a client library for Python programming language called Python API was implemented.

Figure 2 contains an example of program using Python API. It implements a simple diamond-shaped workflow (depicted in the top right corner of the picture) that consists of running four different applications – A, B, C and D.

```
import everest

session = everest.Session(
  'https://everest.distcomp.org', token = '...'
)

appA = everest.App('52b1d2d13b...', session)
appB = everest.App('...', session)
appC = everest.App('...', session)
appD = everest.App('...', session)

jobA = appA.run({'a': '...'})
jobB = appB.run({'b': jobA.output('out1')})
jobC = appC.run({'c': jobA.output('out2')})
jobD = appD.run({'d1': jobB.output('out'), 'd2': jobC.output('out')})

print(jobD.result())

session.close()
```

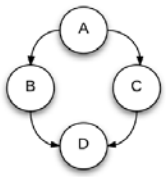

***Fig. 2** An example of workflow described using Everest Python API.*

The nonblocking semantics of Python API, similar to the dataflow programming paradigm, has a number of advantages. It makes it simple to describe computational pipelines without requiring a user to implement the boilerplate code dealing with waiting for jobs and passing data between them. This approach also implicitly supports parallel execution of independent jobs such as *jobB* and *jobC* in the presented example.

Running Parameter Sweep Experiments

Parameter sweep applications (PSA) represent an important class of computational applications that require a large amount of computing resources in order to run a large number of similar computations across different combinations of parameter values. While PSAs can be extremely time-consuming and require enormous amount of processor time, the individual tasks are independent and can be run in parallel.

In order to facilitate running PSAs on distributed computing resources, a generic web service called Parameter Sweep was developed on Everest [5]. At the core of the service is a declarative format for describing a parameter sweep experiment. In order to run an experiment, a user should prepare and submit its description in the form of a plain text file called plan file. This file contains parameter definitions and other directives that together define rules for generation of parameter sweep tasks and processing of their results by the service.

This approach aims to solve a common problem faced by researchers trying to use general-purpose computing tools and environments for running PSAs. Namely, a user have to implement custom programs for generating individual tasks comprising PSA and processing their results. The use of declarative description enables users to minimize or completely avoid such programming work, thus increasing the productivity and accessibility of the developed service.

Upon job submission the user should upload the plan file and application files, and specify resources to be used for running the experiment. Upon submission the service parses the submitted plan file and generates job tasks representing parameter sweep experiment. Then the service passes the generated tasks to the compute layer of Everest which performs scheduling and execution of tasks on specified resources. Upon completion of individual tasks the service extracts task results and performs additional filtering in accordance with post-processing directives specified in the plan file. After all tasks are completed the service produces an output archive with results of the filtered tasks which can be downloaded by the user.

4. Conclusion

The paper described the implementation of Everest platform and its use for automation of computations. The platform, based on service-oriented approach and cloud computing models, enables publication and reuse of computing applications, as well as creation of generic services for automation of common activities, such as parameter sweep experiments. Unlike other solutions, the platform runs applications on external computing resources connected by users, implements flexible binding of resources to applications and provides an open programming interface.

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NEURAL NETWORKS FOR DEFECTIVENESS MODELING AT ELECTRON BEAM WELDING

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Abstract: *This paper considers the process electron beam welding in vacuum of stainless steel 1H18NT. Neural network based models are developed and used for the description of the defectiveness, depending on the process parameters - electron beam power, welding velocity, the distance between the main surface of the magnetic lens of the electron gun and the beam focusing plane and the distance between the main surface of the magnetic lens of the electron gun and the sample surface. Neural network (NN) models, based on a multi-layered feedforward neural network, trained with Levenberg-Marquardt error backpropagation algorithm are compared with NN models, based on Pattern recording neural network, trained with Conjugate Gradient Algorithm. The neural networks are trained, verified and tested using a set of experimental data. The obtained models are implemented to predict areas of process parameters, where the appearance of defects is most probable and the location of welding regimes that should be avoided.*

Keywords: ELECTRON BEAM WELDING, NEURAL NETWORK MODELS, DEFECTS.

1. Introduction

The requirements for the quality of model design and automatic control in the process industries and at the same time the available computing power increased significantly in recent years. This leads to the opportunity of design systems with such intelligent functions as parallel data processing, learning and high-level decision making. Development of adequate models for real industrial processes is usually a complicated task due to the large uncertainties, caused by lack of direct measurements and necessity of inferential approach, high level of non-linearity and different types of disturbances. Building of models accurate enough in a broad range of operational conditions may be successful, if different intelligent modeling techniques are used [1, 2].

The electron beam has developed over the years into a flexible and economic manufacturing tool [3]. Due to the deep penetration in the work-piece, the electron beam is able to generate narrow weld with minimal thermal affected zone and without the usage of welding consumables. The high vacuum required by the method prevents the heated and melted material from oxidizing and affecting by atmosphere's pollutions. With the advanced development of computer control the number of electron beam applications has significantly increased. For the electron beam welding (EBW) technologies new applications the EBW plants has developed into a complex equipment containing highly stabilized power sources and electronic blocks, reliable and effective vacuum system, technology chamber with precision 3D manipulator, becoming truly software controlled programmed manufacturing tool with high efficiency and excellent reproducibility. Technological data gathered during the process enable quality monitoring and support to improve the testing process of the manufactured components as well as to be recorded for future analysis of the relations of adjusted process parameters and weld quality and stability.

The welding quality assurance contains the personnel, equipment and the welding process. For EBW process validation there are available norms and acceptation procedures [4, 5].

The quality of the welds has, so far, shown to be enough adequate in the most cases in spite of the fact that the optimization of the welding process and effects of non-controlled process parameters are still uncompleted. Nevertheless, there is not sufficient statistical data to make analysis of all kinds of weld defects, of root peaks (spikings) and of the flawlessness of the long term weld safety in critical applications.

In this study Neural network (NN) models, based on a multi-layered feedforward neural network, trained with Levenberg-Marquardt error backpropagation algorithm [6, 7] are compared with NN models, based on Pattern recording neural network, trained with Scaled Conjugate Gradient backpropagation algorithm [8, 9]. These models are developed and used for the description of the appearance of defects, depending on the process parameters - electron beam power, welding velocity, the distance between the main surface of the magnetic lens of the electron gun and the beam focusing plane and the distance between the main surface of the magnetic lens of the electron gun and the sample surface.

2. Experimental conditions

An experiment was performed with samples of stainless steel, type 1H18NT [10]. The accelerating voltage is 70 kV. 81 experimental weld cross-sections are investigated. The following operating process parameters are varied: power (P) - 4.2, 6.3 and 8.4 kW; welding velocity (v) - 80 cm/min, 40 cm/min and 20 cm/min; distance between the main surface of the magnetic lens of the electron gun and the beam focusing plane (z_o) - 176 mm, 226 mm and 276 mm and different distances between the main surface of the magnetic lens of the electron gun and the sample surface (z_p) in the region 126 mm and 326 mm.

For the experimentally obtained weld cross-sections the number of defects is counted. For prediction and classification the experimental observations are separated into two groups (classes): 0 – with defects and 1 – without defects. The type of the defects is not taken into account.

3. Neural Networks

Neural networks are universal approximators with low sensitivity to errors, which determines the benefits of their use in different application areas [1, 2].

The modelled EBW process parameters define the input-output structure of the neural network-based model used, i.e. the neural network consists of 4 input neurons, hidden layer (with different number of neurons) and 1 output neuron.

Neural network (NN) models, based on a multi-layered feed forward neural network, trained with Levenberg-Marquardt error backpropagation algorithm are trained and compared with NN models, based on Pattern recording neural network, trained with Scaled Conjugate Gradient backpropagation algorithm.

The methodology, implemented for developing neural network models, consists of the following general steps: choosing the neural network model structure by training of the different neural networks, using the two back propagation methods and the experimentally obtained set of training data, to a satisfactory accuracy and recall of the trained neural network for prediction of the appearance of defects. For comparison of the neural network models the mean squared error (MSE), as well as the regression multiple correlation coefficient or the percent error values are calculated.

For training, validation and testing of the neural networks, the experimental data are randomly separated into 3 parts: 70% (57

datasets) for training, 15% (12 datasets) for validation and 15% (12 datasets) for testing.

3.1. Feedforward neural network

Feedforward neural network consist of a series of layers. The first layer has a connection from the network input. Each subsequent layer has a connection from the previous layer. The final layer produces the network's output.

Feedforward networks can be used for any kind of inputs to output mapping. A feedforward network with one hidden layer and enough neurons in the hidden layers can fit any finite input-output mapping problem. This is two-layer feed-forward network with sigmoid hidden neurons and linear output neurons (Fig. 1). It can fit multi-dimensional mapping problems arbitrarily well, given consistent data and enough neurons in its hidden layer. The network is trained with Levenberg-Marquardt backpropagation algorithm [6, 7].

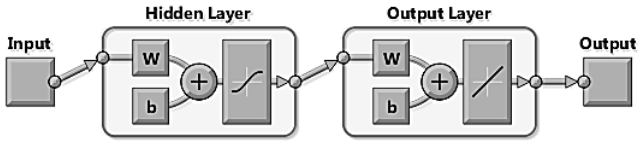


Fig. 1. Feedforward neural network structure

The described approach is implemented for training neural networks with different structures of the hidden layer – with 4 and 14 hidden units and different random sets for training (57 datasets), for validation (12 datasets) and for testing (12 datasets). The best two Neural network models, based on the experimental observations of the defectiveness (0 – with defects and 1 – without defects) are chosen.

The obtained results for the accuracy of the training of these two NN models are presented in Table 1.

Table 1. Feedforward neural network training results

	NN with 4 neurons	NN with 14 neurons
MSE	0.0558	0.0182
R	0.8075	0.9450

In the table are shown the values of the regression multiple correlation coefficient R and the Mean Square Error (MSE):

$$MSE = \frac{\sum_{i=1}^{n}(\hat{y}_i - y_i)^2}{n}$$

where $\hat{y}$ and y is the predicted and the experimental values, n is the number of data. The values of the regression coefficient R measure the correlation between the calculated outputs ($\hat{y}$) and the experimental values y (target T) (Fig. 2). R value of 1 means full coincidence between predicted and the experimental target values and 0 - random relationship. If the value of the MSE is equal to zero, there is no prediction error.

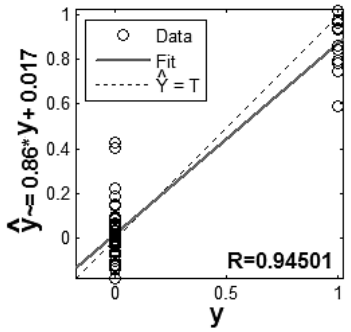


Fig. 2. Best feedforward neural network training results – 14 hidden neurons

The obtained results for the accuracy of the validation and of the testing of the considered two NN models are presented in Table 2 and Table 3 correspondingly.

Table 2. Feedforward neural network validation results

	NN with 4 neurons	NN with 14 neurons
MSE	0.0970	0.0633
R	0.7329	0.8483

Table 3. Feedforward neural network testing results

	NN with 4 neurons	NN with 14 neurons
MSE	0.1899	0.1720
R	0.5182	0.6853

From the tables it can be seen, that from these two structures better results will be obtained by using the neuron network models with a hidden layer, consisting from 14 hidden neurons, due to the smaller values of MSE and closer to 1 values of the coefficient R, obtained during training, validation and testing stages.

3.2. Pattern recording neural network

In pattern recording problems the neural network classify inputs into a set of target categories. A two-layer feed-forward network, with sigmoid hidden and output neurons (Fig. 3). The network is trained with Scaled Conjugate Gradient backpropagation algorithm [8, 9]. It belongs to the class of Conjugate Gradient Methods, which shows superlinear convergence on most problems and it is considerably faster than the standard backpropagation method [8, 9].

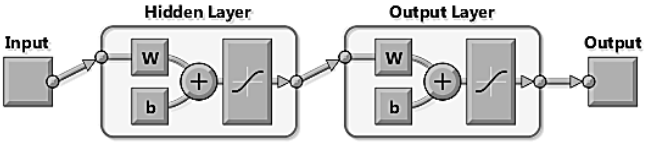


Fig. 3. Pattern recording neural network structure

Again two different structures of the hidden layers are considered - with 4 and 14 hidden units and different random sets for training, validation and testing.

The best two Pattern Recording Neural network models, based on the experimental observations of the defectiveness, are chosen for prediction and classification into two groups (classes): 0 – with defects and 1 – without defects.

For comparison of different neural models the values of the Percent Error (%E) and the Mean Square Error (MSE) are used during training, validation and testing stages. The obtained best results for the accuracy NN models with two structures of the hidden layers during training are presented in Table 4.

Table 4. Pattern recording neural network training results

	NN with 4 neurons	NN with 14 neurons
MSE	0.0109	0.00305
%E	19.29%	1.75%

Percent Error (%E) indicates the fraction of samples which are misclassified. A value of 0 means no misclassifications, 100 indicates maximum misclassifications.

$$\%E = \sum_{i=1}^{n} \frac{|y_i - \hat{y}_i|}{n} \times 100$$

where $\hat{y}$ and y is the predicted classified and the experimental classified values.

The results from the validation are shown in Table 5 and from the testing – in Table 6.

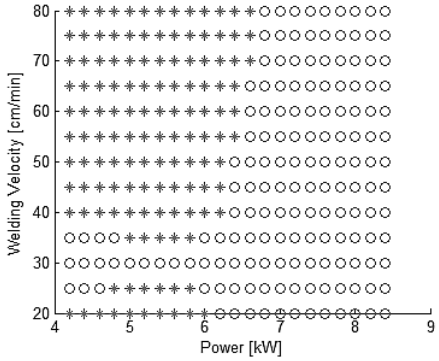
Table 5. Pattern recording neural network validation results

	NN with 4 neurons	NN with 14 neurons
MSE	0.0071	0.0277
%E	0	0

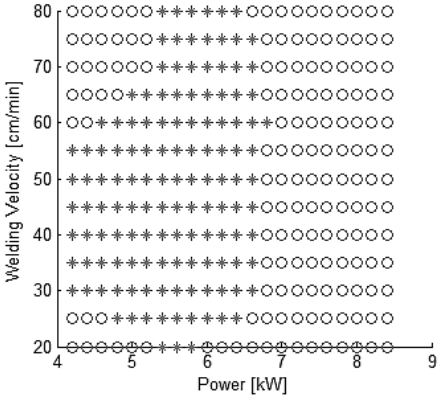
Table 6. Pattern recording neural network testing results

	NN with 4 neurons	NN with 14 neurons
MSE	0.0340	0.0136
%E	0	0

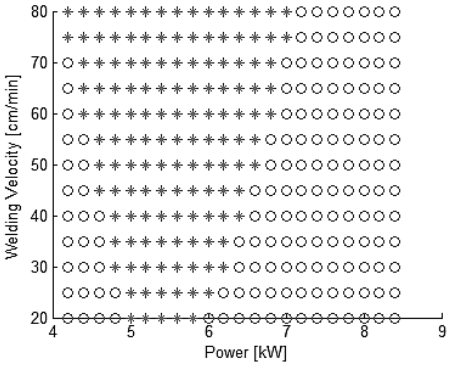
From the tables it can be seen that the trained two pattern recording neural networks have values of MSE close to zero, the first network misfits 19.29% of the observations and the second one misfits only 1.75%. During the validation and testing stages both neural networks have 100% accuracy of the prediction of the presence or the absence of defects at investigated experimental conditions.



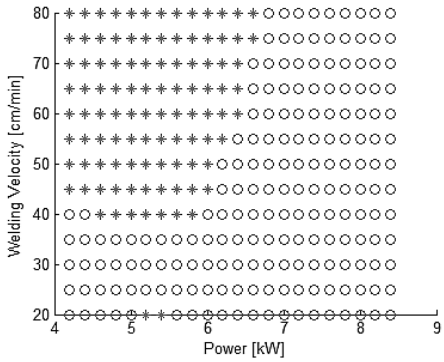
a) Feedforward neural network with 4 neurons



b) Feedforward neural network with 14 neurons



c) Pattern Recording neural network with 4 neurons



d) Pattern Recording neural network with 14 neurons

Fig. 4. Graphical presentation of the areas with ('*') or without ('o') defects at the EBW, depending on the variation of electron beam power and the welding velocity for constant distances z_o = 276 mm and z_p = 226 mm.

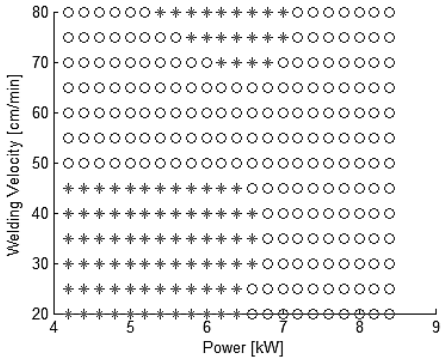
4. Results and discussion

The estimated neural networks are implemented for the prediction of the defectiveness, classified into two groups (classes): 0 – with defects and 1 – without defects, at changing the electron beam welding process parameters: electron beam power (P) and the welding velocity (v). The focus position is chosen to be at a distance z_o = 276 mm from the magnetic lens of the electron gun and the distance to the sample surface is z_p = 226 mm from the magnetic lens of the gun. The electron beam focus lies 50 cm below the sample surface. The type and actual number of the defects is not taken into account.

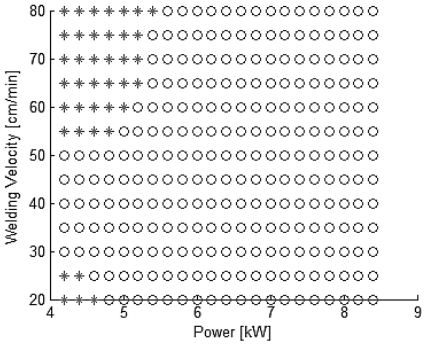
Fig. 4 presents the different areas for the considered process parameters, where the defects will appear (signed with '*') and where there no defects are expected (signed with 'o')

It can be seen that the predicted areas a slightly different, but nevertheless, at the chosen position of the focus 50 mm below the sample surface, the chosen electron beam power should be larger than 7 kW in order to avoid the appearance of defects while the choice of the welding velocity value at these conditions will not affect the defect appearance.

Since the best results for the accuracy from training, validation and testing are obtained from the Pattern recording neural network, trained with Scaled Conjugate Gradient backpropagation algorithm and having 14 neurons in the hidden layer, further predictions should be made by this NN model.



a)



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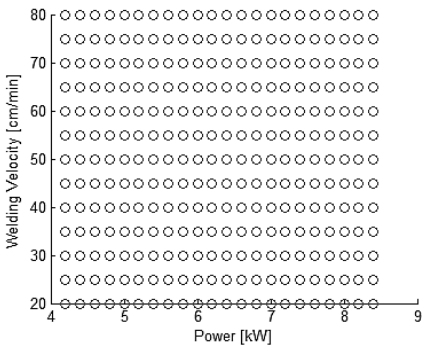

c)

Fig. 5. Graphical presentation of the areas with ('*') or without ('o') defects at EBW, depending on the variation of electron beam power and the welding velocity for constant distances a) z_o = 176 mm and z_p = 126 mm, b) z_o = 226 mm and z_p = 226 mm, c) z_o = 276 mm and z_p = 326 mm.

Fig. 5 shows the predictions of the areas with ('*') or without ('o') defects at EBW, depending on the variation of electron beam power and the welding velocity for different distances from the magnetic lens of the electron gun to the focus z_o and to the sample surface z_p, which correspond also to different positions and distances of the focus toward the sample surface.

Fig. 5a shows again a case of focus position 50 mm below the sample surface, but for different values of the distances z_o = 176 mm and z_p = 126 mm. The beam powers again should be chosen above 7 kW at all welding velocities, while the suggested welding velocities are in the region 50-65 cm/min, if choosing to work at beam powers less than 7 kW.

Fig. 5b presents the result from placing the focus position exactly at the sample surface - z_o = 226 mm and z_p = 226 mm. The choice of the beam power should exceed values of 5.4 kW for all welding velocities, or if working with smaller beam powers, defines working with welding velocities in the region 30-50 cm/min.

Fig. 5c visualizes the case, when the focus position is 50 mm above the sample surface for distances z_o = 276 mm and z_p = 326 mm. It can be seen that no defects are expected within the whole region of variation of the process parameters electron beam power and welding velocity.

During the investigation of other combinations of the distances to the focus and to the sample surface the following generalized conclusions are made in order to avoid defect appearance:

- in the case, when the focus position is again 50 mm above the sample surface for distances z_o = 176 mm and z_p = 226 mm, no defects are expected almost within the whole region of variation of the process parameters electron beam power and welding velocity with the exception of regimes with beam power 8.4 kW and welding velocities smaller than 30 cm/min.
- in the case, when the focus position is 150 mm above the sample surface for distances z_o = 176 mm and z_p = 326 mm, the working regimes that should be avoided is simultaneously working with beam powers larger than 6 kW and welding velocities smaller than 30 cm/min.
- in the case when distances z_o = 226 mm and z_p = 176 mm or position of the focus again 50 mm below the sample surface, the suggested welding velocities are in the region 40-50 cm/min for all beam powers. The area of the process parameter values leading to defects here is the largest.

5. Conclusions

In this study two neural network (NN) models, based on a multi-layered feedforward neural network, trained with Levenberg-Marquardt error backpropagation algorithm and two NN models, based on Pattern recording neural network, trained with Scaled Conjugate Gradient backpropagation algorithm are estimated for description of the defectiveness of stainless steel type 1H18NT welds obtained at electron beam welding. The variation of the following process parameters is investigated: electron beam power, welding velocity, the distance between the main surface of the magnetic lens of the electron gun and the beam focusing plane and the distance between the main surface of the magnetic lens of the electron gun and the sample surface.

From the comparison of the considered structures and different neural networks, it can be concluded that the best results for the accuracy from training, validation and testing are obtained from the Pattern recording neural network, trained with Scaled Conjugate Gradient backpropagation algorithm and having 14 neurons in the hidden layer. That is why, this NN model is suggested for further predictions and parameter optimization.

It was shown that only the position of the electron beam focus toward the treated sample surface is not sufficient enough for the prediction of the areas with defects. The distances from the magnetic lens of the electron gun to the focus of the beam and to the sample surface (z_o and z_p) should be taken into account.

For further optimization the formed weld geometry also should be considered in order to obtain welds with required dimensions simultaneously with the avoiding the defect appearance.

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IMPACT OF COMPUTER AIDED ASSEMBLY TECHNOLOGIES AND SIMULATION IN PRODUCTION PLANNING

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Abstract: *Planning and simulation in assembly processes and whole production systems by computer aided systems is currently an advantage of big major companies. However, computer aided technologies in field of planning and simulation of production systems and assembly systems are future of every one company if they want to remain competitive. Computer aided systems in assembly and simulation of production processes help to save time thus financial resources needed for planning and optimization of every production systems and sub-systems. This kind of computer aided systems are helping to eliminate errors in production processes and assembly systems before they can happen in reality. This paper deals with possibilities of improvement in production process planning by use of appropriate software. In this case we will use Tecnomatix Plant Simulation by SIEMENS company which. Use of this software is aimed for planning and optimizing of production systems with high level of complexity.*

Keywords: PLANNING, SIMULATION, COMPUTER AIDED ASSEMBLY, SIMULATION IN ASSEMBLY, PRODUCTION PLANNING, ASSEMBLY PLANNING, ASSEMBLY TECHNOLOGIES

1. Introduction

Based on competition in international production network we can see that pressure on improving effectiveness of production systems is increasing. International logistic networks need connected logistic concept. These need can be managed only with use of appropriate tools of digital factory in context of product lifecycle management. That enables that output data can be used as base support for cooperation between different departments. It also offers everyday relevant data for every one user who need them. Simulation of complete material flow with all important activities like production, storage and transport activities is key component of digital factory in industry. Lowering the storage capacities by 20-60% and increasing of throughput of existing production system by 15-20% is possible in real life projects. "The purpose of running simulations varies from strategic to tactical up to operational goals" [1].

From strategic point of view users answers the questions like which production plants in which countries are the best for future production of new product with regard on factors like logistic solutions, working efficiency, downtimes, flexibility, storage resources etc. All of this is considered by users for next few years. In this context user evaluate also flexibility of production system. Statistic data is a topic which is becoming more important in present [1].

From tactical point of view is simulation executed for 1-3 months in average to analyze required resources, lot sizes and optimize the sequence of orders [1].

"For simulation on operational level, data are imported about the current status of production equipment and the status of work in progress to execute a forward simulation till the end of the current shift." [1] In this case is aim of the simulation to check final output of work shift and find out if in process we can find some downtimes or accumulated material etc. [1].

In every case user use simulation so they can evaluate new production process or evaluate existing production system. Usually the values acquired by simulation of production process are the main factor in company decision making. So, the user has to be sure that results and statistic data are correct. There are several random processes in real production systems like technical availabilities, arrival time of product, process times of work activities etc. Stochastic processes play important role in simulation of throughput of production. "Therefore, Plant Simulation provides a whole range of easy-to-use tools to analyze models with stochastic processes, to calculate distributions for sample values, to manage simulation experiments, and to determine optimized system parameters [1]." Besides, result of simulation is based on imported data and how precise is virtual model opposite to the existing real production system. When assembly processes, workers with profiles or storage logic, transport systems with controls, production process becomes highly complex. "Plant Simulation provides all necessary functionality to model, analyze, and maintain large and complex systems in an efficient way. Key features like object orientation and inheritance allow users to develop, exchange/reuse, and maintain their own objects and libraries to increase modeling efficiency. The unique Plant Simulation optimization capabilities support users to optimize multiple system parameters at once like the number of transporters, monorail carriers, buffer/storage capacities, etc., taking into account multiple evaluation criteria like reduced stock, increased utilization, increased throughput, etc [1]." Based on precise modeling properties and statistic analysis we can usually get precision of results in throughput at least 99% in real life projects. Return of investment into the simulation software is almost always right after first project. Visualization of project in 3D enables interesting 3D presentation of system behavior. We can basically simulate virtual reality in 3D [1].

In Product lifecycle management scheme is simulation and planning right after concept and right before development stage. PLM is the business activity of managing, in the most effective way, a company´s products all the way across their lifecycles; from the very first idea of a product all the way through until it is retired and disposed of [8].

PLM is the management system for the company´s products. It manages, in an integrated way, all of a company´s parts and products, and the product portfolio. It manage the whole range, from individual part through individual product to the entire portfolio of products [8].

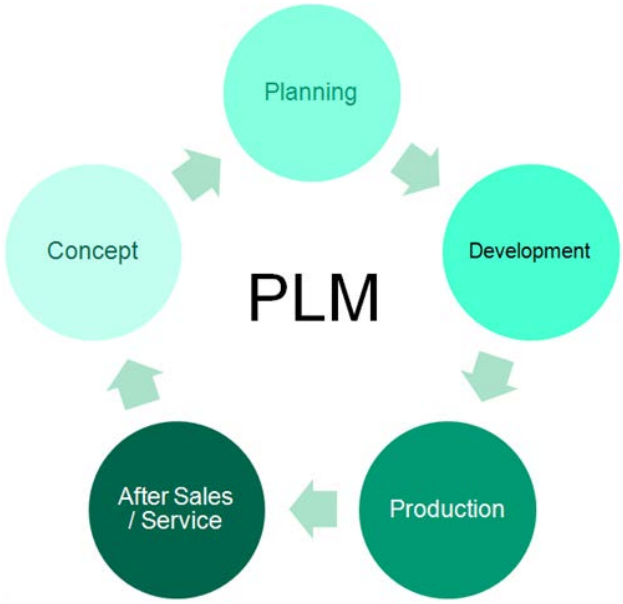

Fig. 1 *Product lifecycle management scheme* [9]

2. Literature analysis

Simulation technology is important tool for planning and implementing of complex technical systems like production and assembly systems. Trends in economy are shortening of planning cycles, and that involves:

- increase of product complexity,
- increase of quality,
- increase of flexibility – shorter product lifecycles of products,
- lower storage capacities,
- increase of competitiveness[1].

Simulation is used where simple methods do not produce useful results[1].

In present exist a lot of simulation software in field of production (more than 100). Prices of this kind of software solutions depends on computer platform, computing power and complexity of use, usually between 2 000 and 200 000 USD. Cost of simulation projects in specialized companies are approximately between 30 000 and 100 000 USD. Even with large numbers like this we always must have in mind that profit is bigger than costs most of the time [7].

Usual main improvements:

- elimination of unnecessary over-dimension of production sub-systems (machines, storage, transport machines etc.)
- elimination of wrong design of production (wrong management, wrong design of material flow or information flow, blocking etc.)

The most used software in market with simulation software are:

- WITNESS (Lanner),
- Tecnomatix Plant Simulation (SIEMENS),
- Quest (Delmia),
- Enterprise Dynamics (Incontrol Enterprise Dynamics),
- ProModel [7].

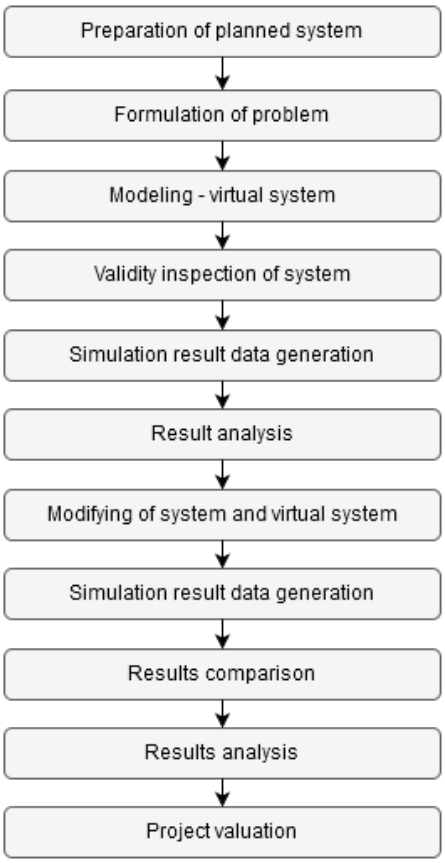

Fig. 2. *Simulation process of planned system*

3. Tecnomatix Plant Simulation

Software that will be used for creation of an example application - Tecnomatix Plant Simulation.

Tecnomatix Plant Simulation (TPS) is tool for designing and optimizing of production systems. On base of simulation is capable to answer the question “what if?”. It can simulate future scenarios in stage of planning. TPS contains analytic tools like statistics, graphs and diagrams which are the reason why results are measurable and relevant. Results obtained by this process have information needed for quick and right decisions in first stages of planning, and they are shortening technological process planning time. Simulations made by TPS disposing by real values by which user can experiment and plan without stopping the production [2].

Advantages:

- testing of innovative strategies in no risk virtual environment,
- maximal usage of production resources,
- lowering the investment risk with help of quick simulation,
- size optimization of systems and storage place,
- quick identification of problems in logistics and production,
- lowering of storage capacities by 20-60% based on size of system,
- lowering the investment costs for new system by 5-20%,
- lowering the employees capacities and manipulation technology,
- quick accomplishment of positive results and identification of effect [2].

4. The example of Tecnomatix Plant Simulation application

At first we need to define what kind of research question we are going to solve by simulation.

Research question:

What are the bottlenecks of production system and how to increase throughput of production process and assembly sub-process?

In this example we introduce digital model which define production system with assembly sub-system. This model is designed in Tecnomatix Plant Simulation software from SIEMENS company. It is production where are needed these technologies:

- cold forming,
- CNC milling,
- polishing,
- drilling,
- assembly,
- quality control.

For assembly is made its own sub-system of four assembly workstations which are simulated as sub-simulation connected to main simulation of production system.

Individual workstations need to have their own time management done by user. Every machine or workstation have chance of defective work. Because of this user needs to set up workstations and machines with certain percentage of defective work outputs. Input into the system is in form of palettes by 10 pieces and simulation interval is 5 days which is one working week.

Time management of workstations:

Table 1. Time management of workstations

Work station	Time (min)
Raw material	10
Cold forming	5
Milling	20
Polishing	10
Drilling	5
Assembly	See table number 2
Quality control	5
Packaging	1

Table 2.Time management of assembly line

Assembly station	Time (min)
Assembly station 1	10
Assembly station 2	15
Assembly station 3	10
Assembly station 4	6

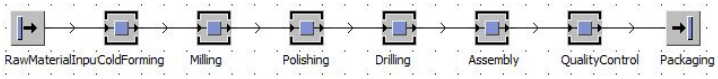

Fig. 3. *Base model of production system*

After designing of base model of production system for simulation was found out that CNC milling workstation is halted by material flowing from cold forming workstation. It was because that CNC milling workstation had longest time interval. Problem was partially solved by adding new CNC milling workstation and one buffer for material.

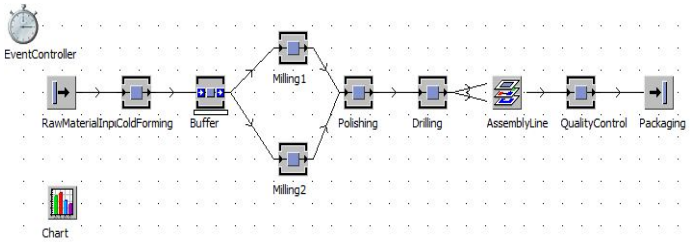

Fig. 4 *Customized base model of production system*

Sub-system of assembly was also designed as a system with four assembly workstations and two inputs of material and one output. Material is flowing from drilling workstation and after assembly sub-process is done, continues to quality control workstation.

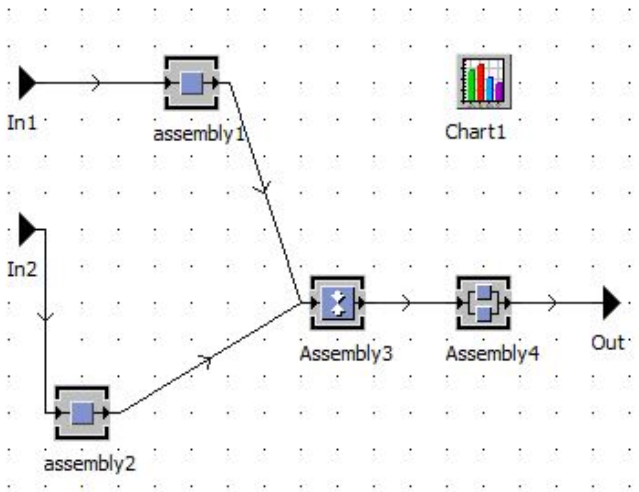

Fig. 5. *Design of assembly line as sub-system of production system*

5. Results and discussion

Customized model of production process was tested and statistical data was generated for each one of the workstations. After that data were compared with statistical data of base model production system.

In base model as you can see in figure number 5 were workstations cold forming, drilling and quality control below value 30% of working status. Workstation polishing was working on 50% and workstation CNC milling was working on 100% because of time management in this workstation. Because milling was the longest procedure, material halted the workstation and buffer was blocked on 70%.

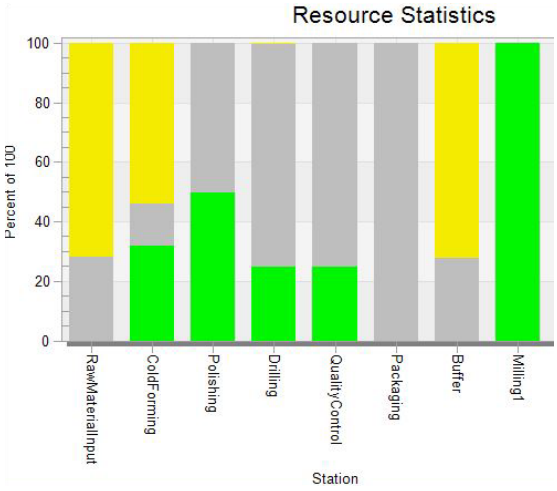

Fig. 6 *Resource statistics of base model*

Legend:

After customization of base model were statistical data changed like you can see in figure number 6. Station of polishing working status changed from 50% to 98% and workstation was blocked only on 2%. Same values were in CNC milling workstations. Workstation cold forming, drilling and quality control increased their working status up to 50%. Buffer was not blocked (0%) thus material was not halting the CNC milling workstations. On the raw material input and output (packaging) is blocking 0%.

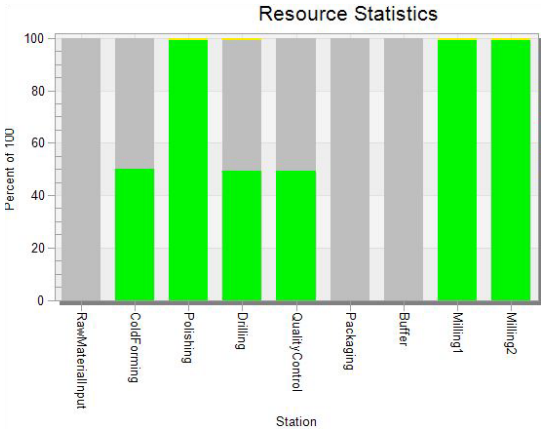

Fig. 7 *Resource statistics of customized model*

Statistic data of assembly sub-system were almost the same as before customization in workstations assembly3 and assembly4.

They changed minimally. But assembly1 and assembly2 workstations increased their working status by 10%. Blocking is minimal on every one workstation.

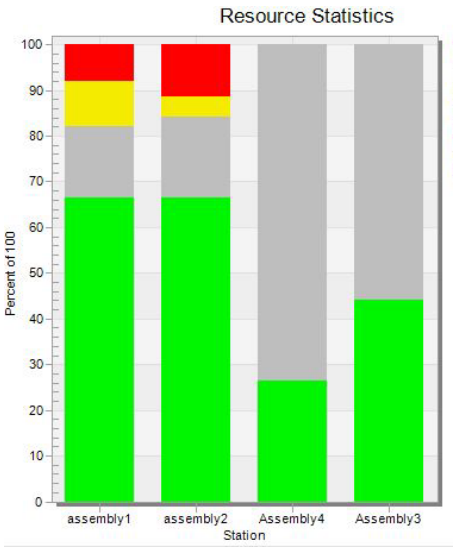

Fig. 8. *Resource statistics of sub-system (assembly model)*

Research question was how to increase throughput and eliminate bottlenecks of production system. As we can see in table number 3, base model has throughput 357 and customized production system model has throughput 711. That is increase by 1,9915 multiple.

Table. 3.

	Base model	**Customized model**
Priechodnosť	357	711

6. Conclusion

Computer simulations which use IT tools became necessary activity which supports design of new production systems and logistic systems or even already existing systems [3]. Simulation methods are used for evaluation different aspects of production systems. Repeatability is basic attribute of computer simulation. Because of exact values and parameters which have their own values assigned to them can be the same process executed many times. In real life this is not possible [5].

Computer simulation warrants with help of IT tools optimization of work and effectivity of whole production system, assembly lines and individual logistic processes. Digital models of logistic systems help companies simulate/test without disrupting the workflow in real production system. Because of testing of different scenarios is possible to choose the best possible alternative of system. This way are effectivity, quality and low production costs guaranteed [4].

Different types of simulation as for example discrete tasks can be applicated in digital models into the different planning activities at different levels of whole production system. Combination of simulations and optimization techniques can improve development of product and planning process of production system [6].

This paper deals with implementation of Tecnomatix Plant Simulation software from company SIEMENS to computer designing of production process. Executed simulations of designed production process showed in example that production system has flaws and bottlenecks. Because of that there was a place for improvements in designed production system with support of selected measures. With simulation we can experiment with different properties and different adjustments of model. It is users choice if it is necessary to change base model structure or just properties of production model. CNC milling machine workstation has working status 98% and blocking status 2%. That wouldn't be a problem if material didn't halt and group before this workstation in buffer. This problem was solved by adding second CNC milling workstation into the virtual model of production system. This solution increase throughput of production system from 357 to 711 (simulated throughput with solution is 1,9915 times the initial throughput of production system).

Acknowledgements

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ENVIRONMENTAL AND SAFETY REQUIREMENTS COORDINATED APPROACH FOR HIGH TECH INVESTMENT PROPOSALS' REALISATION

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Abstract: *The strong industrialized world today need a new sensible approach for further development with high priority to protect and respect the nature, i.e. one rational approach coordinated with environmental and safety requirements for high tech investment proposals' realization. For the aim with the report are defined and proposed the main type of actions for practical application as a combination of legally regulated procedures concerning environmental impact assessment, prevention and control of pollution of the components, identification and application of best technological practices, assurance of operational safety of the plants and protection of the employees, public and environment, using of renewable sources and improving energy efficiency to reach the European "20-20-20" targets.*

Keywords: ENVIRONMENT, SAFETY, REQUIREMENTS, INVESTMENT, REALISATION

1. Introduction

Today, when the world is a very different place for live from the past - for instance for last 500 years the world's population has increased about 15 times, and the world has been industrialized without regard for need to protect and respect nature, - as prerequisite a new sensible approach is needed, namely: Rational approach coordinated with environmental and safety requirements for high tech investment proposals' realization.

In this short report is possible to be showed only a sketch of some problems of safety and climate change, for instance in the energy sector, and the understanding for rational approach for mitigation of these problems. In particular, the approach is presented by high tech investment proposals' realization, aimed finally towards sustainable business development in the energy sector as an example, but applicable in all sectors of the economy.

For the aim, with the report below are defined and proposed the main type of actions for practical application with some examples and suggestions.

2. What is the global reality today and prerequisites for solving the problem

There are lot of examples but today only consumption of energy fuels causes about 150 million tons of CO_2 into the atmosphere every day. The whole world is affected by global warming.

It doesn't matter where are CO_2 emissions into the atmosphere, the earth's rotation and the uneven heating of the atmosphere by the sun ensure that the CO_2 is distributed randomly. That's why the UN negotiations of COP21 - 2015 Paris Climate Conference aim a legally binding and universal agreement for keeping global warming below 2°C above pre-industrial levels.

The energy consumption could be representatively presented with examples for the world, Europe and Bulgaria with several graphics:

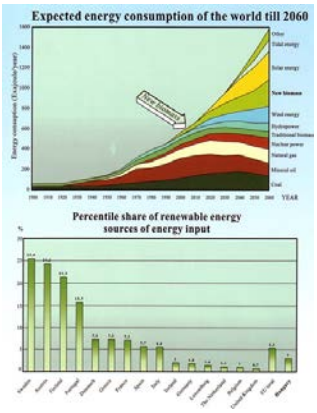

Fig.1 *Global energy consumption and share of RES in EU and some countries (source: Eurostat)*

The energy consumption in EU is more than 60 % on oil and gas and about 6 % on renewable energy sources (RES) – predominately biomass.

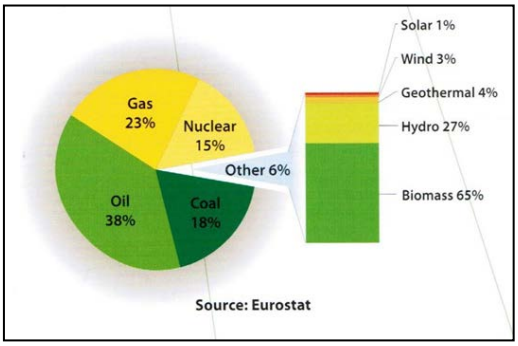

Fig.2. *Shares of energy consumption in EU*

The survey of the opportunities for transposition of Directive 2001/80/EC for Large Combustion Plants (LCP) in Bulgaria shows increased trend after 2000 of the energy composition [1].

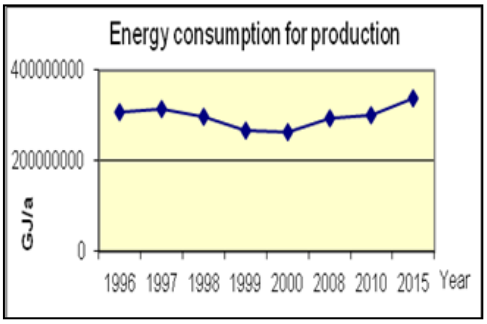

Fig.3. *Trend of the energy composition in Bulgaria*

The energy intensity of the economy by Gross Domestic Product (GDP) *(kg of oil equivalent per 1000 EUR)* by Eurostat' data in Europe is for EU (28 countries) ~ 142, but for Bulgaria the intensity is too big ~ 611, only Serbia has more ~ 653.

Against the background of economy in Europe, the energy consumption and emissions of Green House Gases (GHGs) are unevenly distributed.

In the basis of the definition of EU' "20-20-20" targets in Fig.4 and Fig.5 are shown:

- on the one hand – the needs and energy consumption but not only of the "big players" – Germany, France, UK, Italy….and of the all 28 members and other European countries,
- on the other hand their share in the GHGs production (Eurostat' data)

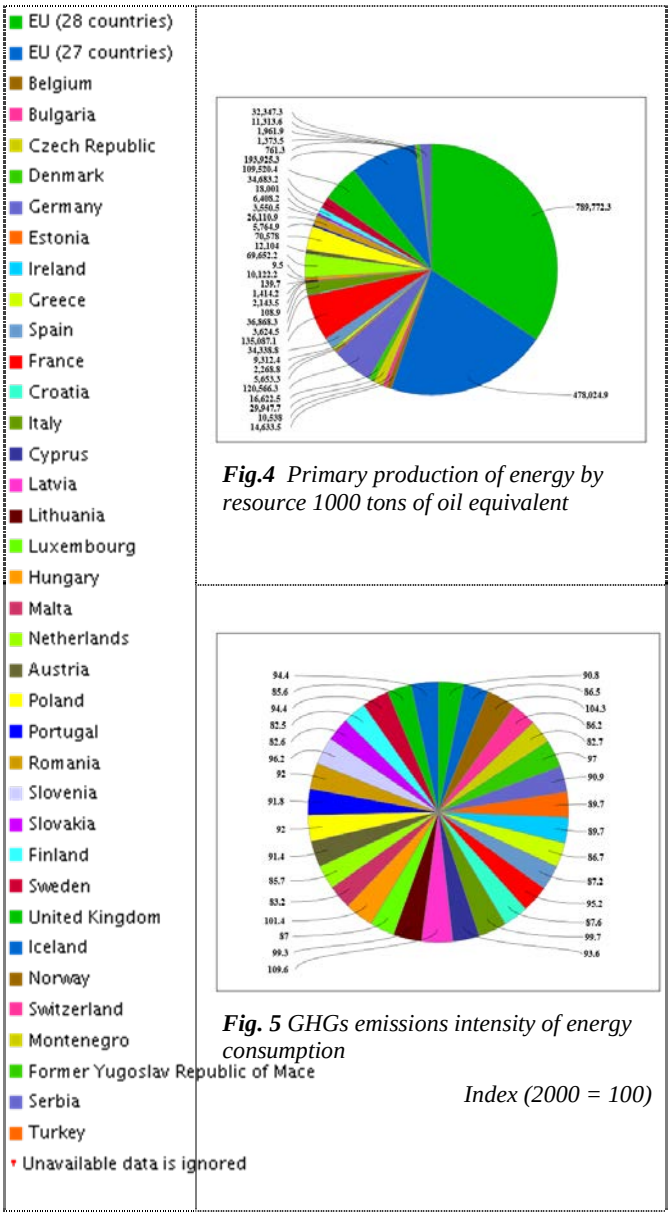

Fig.4 *Primary production of energy by resource 1000 tons of oil equivalent*

Fig. 5 *GHGs emissions intensity of energy consumption*

Index (2000 = 100)

One of the most important challenges of the European Union now in the way to the sustainable development is the climate changes, and thence the goal is to find most rationale decision of the European "20-20-20" targets.

3. Solution of the examined problem - main actions for application of environmentally and safe approach for high tech investment proposals' realization

On the backdrop of the European energy consumption reality, how could be achieved safe and environmental sound sustainable development of the investment process, especially when it comes to major projects at all in Europe, in particular in Bulgaria?

The answer of the question "HOW" could be with applying of rational environmentally and safe approach, including in global aspect for GHG' reduction and climate changes' mitigation, consist in its envelope the follow main actions:

Action-1:

Application of procedures:

- ❖ Environmental Impact Assessment (EIA) and
- ❖ Integrated Pollution Prevention and Control (IPPC),

with relevant zoning and emergency planning.

Action-2:

Application of SWOT analysis as technique of the strategic management, but not ordinary and Extended SWOT analysis for identification of the influences of every project.

Action-3:

Application of **ALARA** Principle (As Low As Reasonably Achievable) in accordance with the relevant legislation and standards for operational safety of the investment infrastructures and protection of the employees, public and environment from hazards and harmful effects.

Action-4:

As supplement to the all activities in accordance with the European "20-20-20" targets, to be achieved 20% of the new enterprise energy consumption to come from renewable sources, and 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

For application of the above actions, the developers and investors in Bulgaria and abroad could rely for performance, research and technical support and/or consulting services of researchers and senior experts from Technical University of Sofia, in particular Safety and Environmental & Engineering Laboratory (SE&EL) at Electrical Power Department.

4. Results and discussion

As example and demonstration of the proposed rational approach here could be presented some results of the steps – on the first place the implementation of Action 1, for instance in the case to consider the assessment and prevention of a power plant' environmental impact and human health risk with the whole public care and responsibility now and for the next generations.

The purpose of the EIA study and report should be defined as follow:

- to study and analysis of possible reasons, sources and levels of impact and determination of potential risk for the environment and human health during construction, normal operation and possible design basis and beyond design basis accidents at the plant, and
- to define recommendations and measures to decrease the impact to the all components of the environment and to the population,
- including on this basis to be determine the risk/emergency zones and thence to be implemented the emergency planning.

The rationale for EIA is based on European and National Regulations of various countries, in particular here for Bulgaria.

So, for instance regarding a construction of a new power plant, or a new unit of existing power plant, in accordance with the European and Bulgarian legislation should be obligatory implemented EIA on the stage "Investment proposal for construction of the plant". After series of implemented projects [2], [3], [4] in this direction from our side and on the basis of our expertise could be recommended the structure of EIA, as follow:

- Introduction
- Part 1. Annotation of the Investment proposal for new plant construction.
- Part 2. Alternatives for execution of the Investment proposal.

- Part 3. Description and analysis of the environment components and factors and their interaction.
- Part 4. Analysis and assessment of hypothetical impact on the population and the environment during construction, normal operation of the new plants and emergencies.
- Part 5. Information on the methods used to prognosticate and assess the impact on the environment.
- Part 6. Description of the measures intended to prevent, decrease or stop hazardous impact on the environment, as well as a plan for execution of these measures.
- Part 7. Standpoints and opinions of the public, competent bodies on EIA, and concerned countries in transboundary context resulting from the consultations held.
- Conclusions
- Appendixes

For instance in Part 5 of EIA for the air pollution assessment applying the Tim's Simple Plume Model by the standard deviations of the plume concentration in the Y and Z directions, the air pollution dispersion could be performed as is shown in Fig 6.

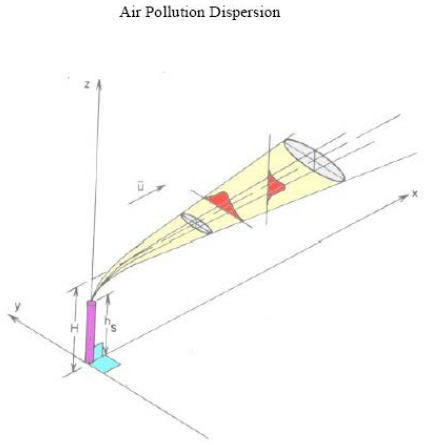

Fig 6. *Spread of the plume by the air pollution dispersion [5]*

As part of the Action 1, the determination of the risk/ emergency zones and thence implementation of the emergency planning, in the general case for instance in the energy sector could be presented as Emergency&Risk zoning reflection in the EIA of the Investment proposal. So, this understanding should be developed in the relevant part of the EIA of each Investment Proposal in accordance with the Bulgarian and European Regulations – of course only for the cases of Investment Proposals where the EIA is obligatory. These under Article 92 of the Environmental Protection Act (EPA) from 2002 (last amendments in 2016), are e.g.: Crude-oil refineries, Thermal Power Plants (TPPs) and other combustion plants with a rated thermal input of 50 MW or more, Nuclear Power Plants (NPPs) and other nuclear reactors, enterprises for iron and steel, ferrous metal foundries with a production capacity over 20 tons/day, installations for the processing of ferrous and non-ferrous metals, enterprises for paper and cardboard, and glass with a capacity over 20 tons/day, etc.

On the one hand the Emergency Planning and Emergency Preparedness measures are stipulated in two Emergency Plans [6]:

i. The External Emergency Plan (EEP) - Emergency Plan, which determines the emergency planning areas/zones and the actions of the competent authorities for the protection of the population, property and the environment in the event of accidents.

ii. The Internal Emergency Plan (IEP) - Emergency Plan of the nuclear facility or the site with an ionizing radiation source which determines the actions of the licensee or the title holder for a solution for limitation of the accident and liquidation of the consequences from it in compliance with the EEP.

On other hand bearing in mind the stages of implementation of the investment project, it was necessary to provide the emergency planning in two respective parts, as follows:

i. Emergency planning up to the start of the operation of the plant (construction stage)

ii. Emergency planning in relation to the operation of the plant and as protective actions during eventual accident and an emergency.

The IPPC procedure in the Action 1 have to be implemented for the plants in operation in accordance with Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (the Industrial Emissions Directive or IED) - the main EU instrument regulating pollutant emissions from industrial installations. The IED aims to achieve a high level of protection of human health and the environment taken as a whole by reducing harmful industrial emissions across the EU, in particular through better application of Best Available Techniques (BAT) in the mayor existing plants.

In the Action 2 the list of SWOT issues should be defined in screening, for instance with the matrix at Fig.7 and their exemplary descriptions below.

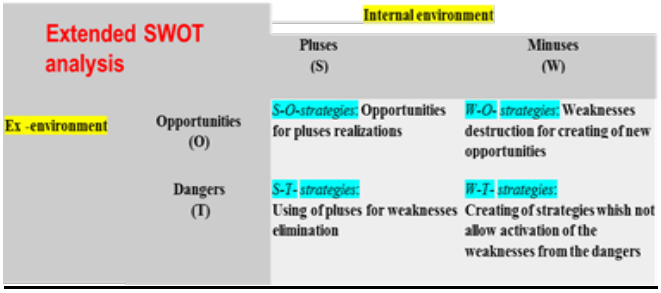

Fig.7. *Matrix of SWOT issues*

S – strengths (pluses): competent human resources, experience in common research, extensive range of expertise, fixed financing from the budget and additional funds from the projects, high qualified human for safety assessment, experience in EU project, expertise with EU projects in other fields of science, well fitted laboratories and software for performing of analysis and assessments;

W – weaknesses (minuses): not enough qualified human resources in the field, direct applicability of results, inadequate human resources management, research is concentrated in the fields, which are partly financed by national sources, Bulgaria can't afford to develop large research programs.

O - opportunities: Financing from national project to cover the studies on innovations, systems and materials, participation in technical meetings, participation at EU Funds, participation in EU calls and international projects, involvement of young researchers in the projects, where it is possible co-operation with neighboring countries.

T – threats (dangers): insufficient number of students of relevant engineering programs at the universities and learners/ trainees in training centers, reduction of funding at the universities, research institutions and training centers, only applicative research, confined opportunities for young specialists in the field, no strategy on national level to define the priorities in development of innovations and research, lower interest for knowledge.

These SWOT issues are more appropriate for national level, but could be modified for the conditions of the relevant investment proposal also.

In the Action 3 applies ALARA Principle. This acronym is formed from the phrase “As Low as Reasonably Achievable.” The phrase refers mainly to a principle of keeping radiation doses and releases of radioactive materials to the environment as low as can be achieved, based on technologic and economic considerations.

Although that, the more than merely best practice, ALARA which is predicated on legal dose limits for regulatory compliance, this principle could and should be applied as a requirement for all safety programs.

The application of ALARA Principle have to be for operational safety of the investment infrastructures and protection of the employees, public and environment from hazards and harmful effects. In all of the cases ALARA have to be in accordance with the relevant legislation and standards. For instance for investments in the nuclear energy sector leading standards are the nuclear safety & security and safeguards standards of the International Atomic Energy Agency (IAEA), general presented in Fig. 8 in three series:

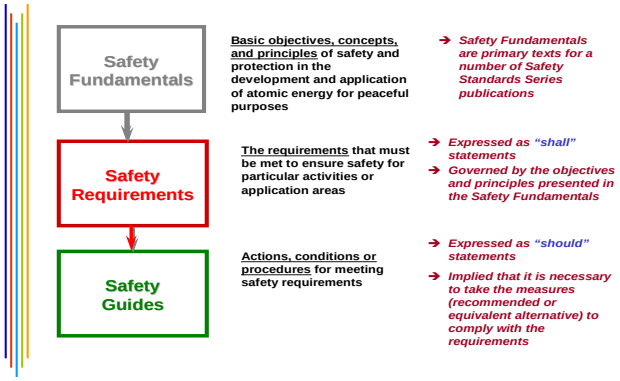

Fig. 8. *Series of IAEA safety standards*

The aim of the Action 4 is to be defined a model of the targets of the Investment in the new enterprise, in harmony and compliance with the European "20-20-20" targets to be met by 2020, namely:

- A reduction GHGs emissions of at least 20% below 1990 levels.
- 20% of EU energy consumption to come from renewable resources.
- A 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

The European "20-20-20" targets should be consider as good practice and to be applied in each Investment in a new enterprise in Bulgaria and everywhere in the world [7] [8], especially concerning the energy consumption to come from renewable sources, and appropriate measures for improving of the energy efficiency.

5. Conclusion

These actions presented above could be considered and accepted from investors and companies on one hand, and also from authorities and municipalities on other hand, in Bulgaria and other countries, not only as reasonable recommendations. These should be taken together with relevant effective measures and activities for possible contribution for global warming' mitigation and achieve of safe and environmentally sound sustainable development of the investment process and the whole economics.

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SECURITY DYNAMICS – ADAPTATION OF ICT INFRASTRUCTURE TO CLOUD COMPUTING – THREADS AND OPPORTUNITIES

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Abstract: *The adoption of new technologies in organizations requires a preliminary assessment of risks, pro and cons of the planned change (SWOT analysis and change management). This paper acknowledges the important changes which are occurring in the security of the ICT systems in the organizations as a consequence from the transfer to the cloud services.*

Traditionally, IT is positioned behind the firewall of any organization and all servers, virtualized or not, are specific as a service for any business. The authority which supports the security systems could choose the components for security among multiple proved products – firewalls, antivirus systems, servers, updates management, proxy servers, etc. In this way is guaranteed the high level of control upon the security of IT environment and the requirements of different standards for security.

Keywords: SECURITY, ICT INFRASTRUCTURE, CLOUD COMPUTING, DYNAMICS

1. Introduction

In the Cloud infrastructure the servers are virtual and are shared between different organizations with different kind of business. In case, the team of an organization is necessary to get together all resources from a public cloud, which is located in Singapore for instance, with the private cloud located in England, then the team could not make use of proved and matured products on the market in order to guarantee the security of the connection. This could lead to reduced trust in the security of Cloud environment [3].

2. Adoption of ICT infrastructure to Cloud Computing

In this section we discuss an example of an organization that has a well developed security of ICT system and it includes well subsystems for:

- application of updates of all operational systems (OS), applications, network devices, printers, and UPSs;
- assets management, taking into account all platforms with details for the hardware, installed software and its utilization.

With the invent of Cloud computing the requirements to the functions of the above mentioned subsystems are changing. In this case, the architecture is based on two or more distant data centers and hypervisors with virtual machines (VM) in them. The VM could be on, off or in snapshot mode.

The subsystem for updates has to keep track of all VMs from all data centers of the provider and to influence on them, because when one VM is moved from one data center to another it could be left without update. The process of update has to be linked with the subsystem of the asset management as in the subsequent need for update all VM machines that are stopped and the ones in snapshot mode will be missed.

We feel that the subsystem for asset management, combined with a function for monitoring of VM dynamics and in compliance with the cloud infrastructure, can be the second pylon after the updates, on which to base overall scheme for security management of the VMs.

In Table 1 below are presented the basic processes which are leading to new requirements for updates and monitoring of the security of VMs in the dynamics, typical for their life-cycle in Cloud environment.

Table 1. *Basic processes leading to new requirements for updates and monitoring*

Term	Process	Description
On/Off	Some VM stop and start many times in a short period.	The virtual machine is created, used and destroyed before it is checked and updated [5]
Snapshot Rollback	Rollback	The return of the virtual machine from the pre-stored image in a previous condition can lead to non updated versions of one or more applications [5]
VM Migration	Transfer of virtual machine	The virtual machine is copied, without being stopped or at a standstill, in another data center infrastructure provider of cloud services. It is related to a change in the DNS and other problems.

The Reflection of Elasticity

Key difference between Cloud computing and conventional data centers is the elasticity. It is essentially a key character of virtualization. Servers are as file and executable tasks, and may be subject to various operations – copy, moving, resize of the elements of the OS, disk space, number of network controllers, snapshots, reserved templates with the aim of next backup.

The elasticity gives possibility of the organizations to multiply the servers: their number is growing quickly as well as the available power for computing. This increases the risks of compromise since:

- When coping the server all its undiscovered and exposed vulnerabilities are also duplicated;
- Coping the servers is dramatically increasing the total area for attacks in the data center.

The non-active images of servers as well as the snapshots are VMs which saved in files and are intended for subsequent reactivation or serve as templates for new servers. This advantage is at the expense of security: as these machines are not active when installing security fixes, they remain unprotected from newly discovered vulnerabilities, without configuration changes with

changes in policies and does not reflect the change of access rights for the users [6].

An incorrectly configured server can be replicated in cloning of new servers and to become an outbreak of the entire server farm of the supplier. The elasticity involves security issues that do not exist in traditional data centers.

It becomes necessary functions of monitoring security, which include:

- AAA control that manages who may request additional resources from pools of shared resources or to release used resources;
- Monitor and audit requests to obtain and release resources to ensure that quotas are met and services remain available;
- Providing guaranteed deletion of residual data from all components of the pool with consumed by the tenant resources.

From the perspective of the tenant it is necessary to have a sense of infinite capacity resource. From the perspective of the provider of cloud services he owns a pool of fixed size that contains shared between tenants' resources and must be managed so that the conditions for quality of the service are met [8].

Ready Virtual Machines (VM)

In recent years, all manufacturers of devices for protection - firewalls - IDS /IPS, UTM, anti-spam devices, antivirus devices started to offer ready-made virtual machines [1] to test their products and real application environments virtualization. Separately, there are many small and big manufacturers of ready virtual machines that can be copied from the Internet and to be applied directly to virtualization environments.

Large manufacturers offer tools to prepare their own VM and virtualization of existing production platforms on real hardware to be transferred in an environment of hypervisor for a variety of reasons, such as increasing trend for hardware problems [7].

The production of VMs with ready-installed applications and their marketing brings threats that in our opinion are in most cases similar threats from uncontrolled copying of software from Internet sites and installing it on the office computers.

Initially, ready VMs were designed for traditional data centers with server for virtualization, but today the focus of their application moves into cloud computing [2],[3]. What effects might cause this?

In the environment of the provider of cloud services may fall machine that is compromised or such that is prepared and provides tools for implementing the attacks of various types. Publications on the subject are mentioning possibilities to implement the tools bot-net, DLP, DdoS, theft of encryption keys [4].

What could be the approach to this threat? For example, such as applications for virus detection on the images of VMs that are offline or testing in isolated mode.

As well, it would be very much useful if we have an asset management which may keep in dynamics the report on all VMs together with the applications on them and even their licenses, regardless how long they have existed.

3. Securing Internet of Things (IoT) Devices

The coexistence of many tenants in a cloud environment is another aspect of the security of virtual machines. Joint persistence of virtual machines that are owned by different tenants in a cloud environment poses a range of risks which is our next research direction to explore.

Nowadays Internet of Things (IoT) is a natural extent of conventional ICT. It comes with BYOD and many smart devices and the big data. The staff takes care after installation of the smart devices, WSN, IoT middleware and the cloud services are not proved for security. All this extend the surface for attack.

IoT manufacturers use cheap components and boards for the most parts which lack the power or capability to run fundamental security features, such as anti-malware, anti-virus, firewalls and encryption. These devices are thus left not only vulnerable, but worst, making them virtually impossible to secure. As for the IoT devices, the direction towards solving this security threat will require a combined effort from consumers, manufacturers and technicians.

IoT connected devices should always exist behind a Firewall. Moreover, the default firewall settings and passwords of many WiFi routers and devices are not adequate to block such traffic. Usually, it is not the case that the end users could hire an expert to audit the home or office network security. By 2020, it is estimated that the number of connected devices is expected to grow exponentially to 50 billion.

To address the security issues at the manufacturing level of IoT devices, there needs to be strict security standards and regulations put in place. This however, is a huge effort. Meanwhile, many IoT devices will become obsolete or even be returned. With newer versions being released, manufacturers have more opportunity to built-in security. Security staff should investigate and compare solutions which focus on protecting all on-premise devices, for example gateways with embeded firewalls which add a layer of protection in front of IoT devices. This is extremely important because, as mentioned, IoT devices often have limited computing resources and for the most parts are unable to manage their own security on-board.

Incorporating security into the design of components used in the IoT is essential for securing the operations of the IoT and the cyberphysical infrastructure upon which society depends. The penetration of IoT and its part in the critical infrastructure requires incorporating security into the design of components. Given the increasing functionality, interconnectedness and use of the IoT within critical infrastructure, securing the integrity of command and control within the IoT is essential.

There are several challenges to incorporating security into the design of IoT components. These challenges are as follows: (1) precisely describing confidentiality and integrity policies in ways that are amenable to formal reasoning, (2) maintaining logical consistency among confidentiality and integrity policies and implementation at all levels of abstraction, from high-level behavioral descriptions at the user level, down to implementations at the level of state machines and transition systems, (3) Incorporating confidentiality and integrity policies into current design flows, and (4) providing certifiers with compelling evidence of security that they can quickly and easily reproduce and verify for correctness.

Together with IoT invasion there are existing already installed automated systems such as: Building Automation Systems (BMS), Industrial Control Systems (ICS) and SCADA. IoT would coexist with such kind of systems in synergy and would add smart properties to those kind of systems.

This would lead to new extend of attack surface. Potentially vulnerable existing BMS are now prevalent in many buildings and offices, including hospitals, airports, sports stadiums and government departments. The environments of these organisations are therefore vulnerable to outside control; control that has the potential to impact external and internal communications, computer networks, building access, lighting and heating. Downtime on every single system has a direct influence to the wellbeing of people, the performance of businesses and the corporate reputation of organisations, institutions and entire industries. Would a hospital with no lighting be able to treat patients? Could an airport function without communications for a whole day? How would a business operate if its staff could not access its building? Such attacks, even if quickly resolved, could cause untold damage in fragile systems that rely on continued operation, such as electricity generators, casinos, hospitals or stock exchanges, to name a few. Organisations would cease to function and potentially collapse, taking down their reputation as well as severely inhibiting their commercial

performance. There are multiple reasons behind such attacks (See Table 2) as follows:

• Activist groups wanting to break up organisations they take issue with

• Terrorists wanting to disrupt national functions, for example transport or government operations

• Nation states wanting to harm organisations they consider a competitive risk or a threat to their security

• Companies wishing to sabotage competitors

• Aggrieved former employees wanting revenge

• 'The bored teenager' testing his hacking skills.

If those actors gain control of BMS, the damage that can be done is highly significant [9]:

Table 2. *Impact of compromise to the system [9]*

System	Impact of compromise
Management System/ Dashboard	Lockout genuine users from system
Lighting	• Deactivation of lights may cause safety and productivity issues including public panic and inability to conduct business as usual • Flickering of lights could cause health issues • Increased situational awareness for criminals by activating lighting remotely • Reduces situational awareness for guards/ CCTV operator by deactivating lighting remotely
Access Control	• Remote release of secure doors resulting in unauthorised access • Deactivation of door release to inconvenience users/force use of green break glass • Deactivation of authorised users • Addition of unauthorised users • Erasure of access logs to cover criminal activity
HVAC	• Deactivation of cooling to cause plant/ ICT equipment to overheat/shutdown/ malfunction • Activation of heating to cause plant/ ICT equipment to overheat/shutdown/ malfunction • Deactivation of cooling/heating making normal working difficult or sometimes impossible
CCTV	• Increased situational awareness for intruder to be able to see guard locations and blindspots • Ability to turn cameras away from criminal activity • Ability for intruder to erase footage • Ability to capture sensitive information such as passwords, sensitive business details or private activity that could cause embarrassment if made public
Lifts	• Denial of service • Override lift access control
Tenant Billing	• Tenant's under or overcharged for utility usage, affecting profitability or alienating customers
Building Information Modelling and CAD	• Criminals have a greater awareness of where key systems are located and how they are connected and powered
Building/ Perimeter Intruder Detection System	• Deactivation of system allowing unauthorised access • Creating false alarms for distraction • Erasure of event records to hide criminal activity
Fire Detection	• Cause panic and disruption by activating alarm or risk lives by deactivating it (Note: We assume that fire detection would not be under the control of the BMS to comply with standards therefore vulnerabilities should be limited, but this may change in future)

The threats from IoT increases by a number of factors (see also Fig.1):

- The number of connected "things" anticipates the possibility to be controlled, monitored and organized;
- Many devices have little or no any built security;
- There is no any standard procedure for securing the devices for Internet of Things, even there are no any best practices;
- An increasing number of devices provide access to personal information;
- Demand for business opportunities with this class of devices and systems will continue to be a higher priority than their security.
- Connecting plain old automation systems that are designed without security in the requirements to IoT. Devices that were never built up for security are increasingly becoming connected to networks, and so becoming hackable.

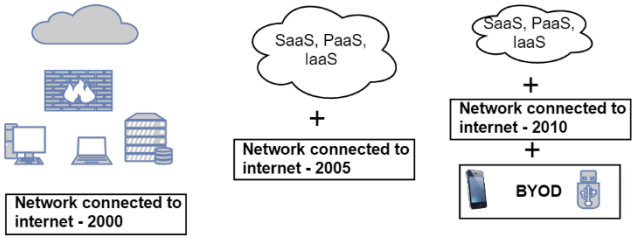

Fig. 1. *Growing threat landscape factors from 2000 to 2010*

The challenge are the above mentioned unconnected areas: asset/ facility management and IT. But, as more BMS become connected, the more departments need to work closely together, or facilities managers need to become security experts. See Fig. 2 below.

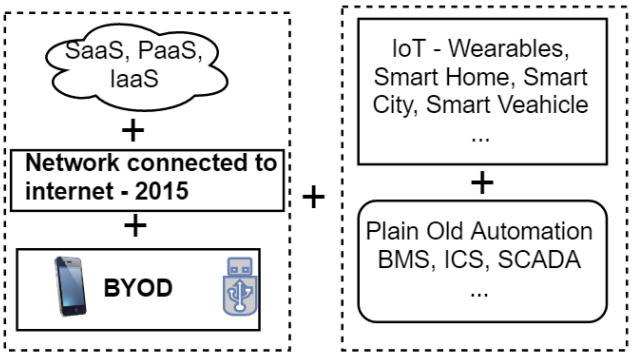

Fig. 2. *Extension of threat surface after 2015 with IoT and old automation system*

3. Conclusion

In the present paper the attention is on the main aspect of the above mentioned new level of synergy between Cloud and IoT concerning security, taking into account that this is a new ecosystem of business relations. So, the paper through light on trends of security risks that are hidden in this kind of supply chain.

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VARIOUS TECHNIQUES IN SOFTWARE APPLICATIONS FOR 3D VISUALIZATION AND EVALUATION OF BIOISOSTERIC MOLECULES

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Abstract*:The best - known software applications for 3D visualization and evaluation of bioisosteric molecules will be compared. The software applications are based on parameters, which can be divided mainly into two directions - emphasizing electrostatic properties, wave functions and presence of electrons in different energy states, and QSAR - based - quantitative methods – empirical examination of molecules, which use mainly statistical data collection, thus evaluating the properties of molecules through regression models to investigate similarity. The first group of innovative methods are superior, because of their analytical purposes that are not mining blindly for bioisosterism through empirical statistical data, but analytically detect similarities according to molecules' shapes. In conclusion - the use of GPUs for parallel processing of matrix-based operation - for the calculations of quantum vectors - would lead to repeated acceleration of the speed of these calculations. Finally, this study demonstrates the GPU as another factor, which is important for the improvement of the evaluation methods of studying and visualization of molecular similarity.*

Key words: 3D visualization, bioisosteric molecules, software applications, innovative methods, bisisosterism, GPUs

1. Bioisosteres In Drug Discovery

Bioisosterism has a crutial role in the development of drug molecules almost from the origin of the pharmaceutical industry. The aim of bioisosterism is that the properties of a compound can be fine-tuned without affecting its fundamental biological activity. However this comes with its challenges. Successfully applying bioisosterism to achieve the intended molecular outcome is difficult because of the fundamental problem that chemical structure is an unreliable indicator of biological activity. A slight change in a molecule can have a far-reaching impact on a compound's activity, specificity and toxicity, in the same time completely different chemotypes may have near identical biological activity profiles. More exact and reproducible methods for suggesting relevant, non-obvious and yet synthetically intuitive bioisosteres would have wide applicability.

Bioisosteres are used by researchers throughout the pharmaceutical industry to find new hits and leads by modifying known actives or substrates, to develop leads by modifying physicochemical properties and protecting their knowledge using patents. Having identified an interesting target, researchers often had little choice in finding an active inhibitor or antagonist, except through bioisosteric modification of the natural ligand in a systematic and thoughtful manner. The modern HTS era has provided a lot of potential leads, but still the need for bioisosteres stays actual as structures found through HTS can have undesirable properties (either physical or biological) and often lack novelty.

The requirement to protect research positions through patent applications is crucial for the development of new medicines. In this respect, IP protection is probably the most important use of bioisosteres in the modern drug discovery project. Replacement of core groups in the lead series with new scaffolds that introduce better selectivity or physical properties. Scaffold hopping is a computational technique of replacing portions of molecules to create novel drug-like compounds with similar activity to the original. The method involves choosing a portion of the starting molecule, often the central scaffold, for replacement. The scaffold-hopping software searches a database of hundreds of thousands of fragments for the best replacements. The worth of the software depends on the algorithm used to evaluate the "best" matches. Different software tools use different approaches. Some use simple geometrical considerations and/or the presence of simple pharmacophore points while others use ligand similarity to rank the replacements. In all cases, the best matches are returned as possible candidates for synthesis. Choosing the right compounds to progress is important as it can frequently take up to a week or more of lab time to synthesize a new compound. Results must be imaginative, yet realistic suggestions that enable users to advance the compounds that are most likely to succeed.

High-throughput screening (HTS) is a method for scientific experimentation especially used in drug discovery and relevant to the fields of biology and chemistry. Using robotics, data processing and control software, liquid handling devices, and sensitive detectors, High-throughput screening allows a researcher to quickly conduct millions of chemicalor pharmacological tests. Through this process one can rapidly identify active compounds that modulate a particular biomolecular pathway. The results of these experiments provide starting points for drug design and for understanding the interaction or role of a particular biochemical process in biology. It still takes a highly specialized and expensive screening lab to run an HTS operation, so in many cases a small- to moderate-size research institution will use the services of an existing HTS facility rather than set up one for itself.

Methods for describing molecules in a manner more related to their biological activity would have the potential to enable modifications and research activities to progress in a more sufficient way. The goal for finding relevant, non-obvious, accurate bioisosteres is not lucking an interest. These methods broadly fall into two categories: knowledge-based approaches and computational techniques.

2. QSAR software applications (legacy)

Knowledge-based approaches tend to use data mining techniques to find component parts that have previously been substituted for each other without a significant change in the activity under study. This approach has broad appeal; it can highlight changes that are known to be successful together with detailed examples. However, many replacements are specific to a particular protein and take no account of which parts of the moiety to be replaced are most important for activity. Equally, if the moiety to be replaced is not present in the literature then no suggestions are possible. The variety and availability of computer algorithms to suggest bioisosteric replacements has increased significantly in recent years. Most methods attempt to excise a chosen moiety from a molecule and replace it with a fragment from a fragment database. These fragments are typically scored against the moiety to be

replaced using shape or electrostatic measures of similarity, or by using the presence or absence of pharmacophore points.

The concept of "Structure-Activity Relationship" (SAR) is that the biological activity of a chemical can be related to its molecular structure. When quantified, this relationship is known as "QSAR". A QSAR model makes use of existing experimental toxicity data for a series of chemicals to build a model that relates experimentally observed toxicity with molecular descriptors in order to predict the toxicity of further chemicals. Quantitative structure–activity relationship models (QSAR models) are regression or classification models used in the chemical sciences and engineering. Like other regression models, QSAR regression models relate a set of "predictor" variables (X) to the potency of the response variable (Y), while classification QSAR models relate the predictor variables to a categorical value of the response variable. In QSAR modeling, the predictors consist of physio-chemical properties or theoretical molecular descriptors of chemicals; the QSAR response-variable could be a biological activity of the chemicals. QSAR models first summarize a supposed relationship between chemical structures and biological activity in a data-set of chemicals. Second, QSAR models predict the activities of new chemicals.

Principal steps of QSAR include a selection of Data set and extraction of structural/empirical descriptors, variable selection, model construction and a validation evaluation, based on the principle - Structure–Activity Relationship (SAR) - that similar molecules have similar activities.

VEGA software

Several institutes contributed to the development of the platform, called VEGA - QSAR, including regulators and public bodies in Europe and USA. VEGA freely offers models for properties.

The steps of the workflow include insert the list of the molecules identifiers, choose where to send the prediction output, ask prediction, and get results. The input can be given in different standard formats used in the chemical domain, including SMILES and SDF. To avoid the well - known problems about the non-unique representations VEGA transforms all the chemical structure into a unified internal string format.

The overall reliability of the prediction is measured by combining statistical values, elements of case based reasoning, and possibly presence of active substructures; the possible reasons of concern are underlined. All those considerations are weighted and summed up in an index (in 0 – 1) that is called Applicability Domain Index (ADI).

All of these methods seem to suffer the same problem: they rarely suggest truly novel scaffolds to the researchers. The reason for this is not clear but the one commonality is that these computational methods, like the literature methods, rely on fragment-to-fragment comparison. In this method, the replacement fragment is scored as an isolated molecule in itself, and not in the context of the final molecule. This is a subtle but critical problem, which Innovations in Pharmaceutical Technology means that there is no possibility for the properties of the fragment to influence the properties of the final molecule. Moreover, as the final molecular context of the fragment is not considered, fragments that might represent only a small change to the final molecule in its entirety may be scored poorly because they represent a large change when scored at the fragment level.

3. Analytical visualization software applications (innovative)

The Field Point approach is describing molecules by encoding the electrostatic environment surrounding a ligand. Drawing out the full field down to a series of 'hot spots' around the molecule – termed 'Field Points' – provided both a powerful insight into the behavior of molecules and a mechanism by which molecules could be compared in a computationally efficient and therefore rapid manner. Field Point descriptions of molecules have been used extensively to provide richer, more informative views of the way in which ligands interact with proteins, to interrelate compounds from different chemical series that act at the same protein site, to find novel chemical series through virtual screening, and to decode Structure Activity Relationships (SAR) by comparing molecules as proteins 'see' them. Field Point technology can also provide a much more accurate basis on which to identify novel, chemically relevant bioisosteres.

The principle behind fragment replacement methods to identify bioisosteres is simple: remove a portion of an active molecule, search a fragment database for a replacement moiety that will physically fit into the vacated space, and score the replacement for similarity to the original. In practice, a number of factors contribute to the effectiveness of the method. Primary amongst these are the accurate scoring of potential replacements, the relevance of the fragment database, and the originality and synthesisability of the suggested bioisosteres.

In scoring replacement fragments, it is essential to remember that the molecular fields around them are a property of the whole molecule and not of the isolated fragment. Replacement fragments cannot be assessed accurately in isolation from the whole molecule as they can have a significant effect on the retained portions of the molecule. Not only will fragments that are strongly electron donating have different effects from ones that are electron withdrawing, but the context of the molecule into which they are placed will determine the extent and character of those effects. To this end, we chose to join replacement fragments into the retained portions of the target, minimising the energy of the result to ensure sensible geometry, before scoring the whole of the proposed new molecule against the original molecule using Field Points. This approach, using the fields of the whole molecule, is only tractable because of the significant computational advantages provided by Field Point representation.

Because the score is based on the whole molecule, any effects that the new fragment may have on the original molecule are automatically considered. This process gives a results list that is significantly richer in non-obvious bioisoteres than would be the case had we only considered the isolated fragment. Using the whole molecule has an additional benefit in that the medicinal chemist is presented with a list of potentially active molecules rather than partial fragments. This allows them to select molecules for synthesis more easily without mentally having to construct and retrosynthesise the final molecule.

SPARK SOFTWARE

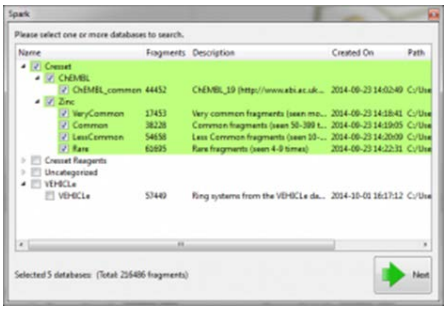
Delivers software to help to discover, design and optimize small molecules. The scientific methods use 3D molecular electrostatics and shape to shed light on the properties and behaviors of chemical structures and, crucially, to understand the key interactions which underpin biological activity.

Spark finds biologically equivalent replacements for key moieties a molecule for R-group exploration, patent busting or scaffold hopping. Allows visualizing of the results in detail side-by-side, or cluster similar chemical scaffolds and Search for moieties from real, published or unexplored compound databases. Spark is available on Windows®, Os X® and Linux®. It can be accessed as desktop applications and command lines and KNIME™ and Pipeline Pilot™ nodes.

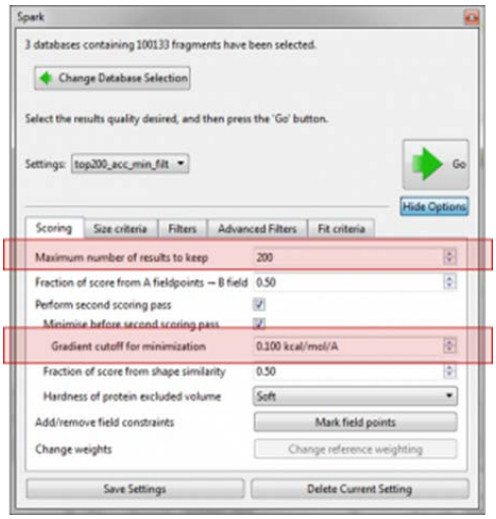
The Spark CSD Fragment Database is a collection of fragments derived from the small molecule crystal structures in the Cambridge Structural Database (CSD).

Experimental Setup starts with a load of the pdb file of the molecule is loaded into Spark and split into ligand and protein using the new protein import facility. The head group of the ligand for replacement is chosen and then selected the search of the

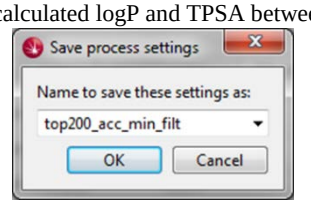
Chembl_common, VeryCommon, Common, LessCommon and Rare databases.



Before starting the experiment some of the parameters can be altered, for example on the 'Scoring' tab the number of results can be limited and the minimization of the final molecules can be improved by decreasing the gradient cutoff during the minimization.



The 'Advanced Filters' tab can be used to control the physical properties of the final molecules so that can be selected omly molecules with a calculated logP and TPSA between set borders.



In conclusion the advantages of Spark are a simple fast (less than an hour duration) experiment that is able to detect not only a large number of known scaffold replacements, but also structurally-novel suggestions in clear IP space. The new tile view allows the results to be rapidly triaged by eye, allowing the focus in on the most desirable replacements quickly and easily.

4. *Application of the Graphical processing unit in the field of Bioisosterism*

4.1 Parallel Computing

Even though supercomputers have kept a substantial lead over even the most sophisticated desktop machines in the continuous competition of hardware for speed, capacity, and robustness of computer platforms, the use of supercomputers has been considered a privilege to a limited number of people. In one important aspect — delivery of the technology to the fingertips of the largest number of people — parallel computing has always been at a disadvantage. Large academic institutions, large corporations, and government organizations can afford to execute computing tasks on customized supercomputers. As the name entails, algorithms executed on parallel computers and implemented in MPI (Message Passing Interface) have proven to be vastly superior in terms of time performance [2], which however comes at a high price: depending on the number of processors, and therefore computational potential, supercomputers can be priced anywhere upwards of several thousand dollars to build. Moreover, demand for computing frequently will be greater than the available processing time, requiring the process to be delayed in a scheduling queue. The resources and personnel required to establish and to keep a cluster operational are economically justifiable only in rare occasions.

To address the affordability problem, NVIDIA Corporation made available in the end of 2007 its proprietary platform for parallel programming, CUDA – Compute Unified Device Architecture [3]. The platform has two components: (1) hardware - the NVIDIA Graphics Processor Unit (GPU) on the graphics card; and (2) software - the programming interface to the GPU, provided by the CUDA language. As initially intended, the parallel computational capability would provide for efficient graphics rendering operations, where simple, independent algebraic calculations must be executed. The native carrier for graphics information is the **matrix**, stored in memory in the form of an *array*. Thus, graphics cards have gradually undergone a natural evolution to become robust platforms for matrix operations in parallel, a virtual requirement for all modern video-editing and gaming software.

An example of a problem that is suitable for a parallel implementation is the operation of matrix summation, A + B = C. The sum of elements in row *i* and column *j* of both matrices, A*ij* and B*ij* , is recorded in element C*ij* . This operation is *independent of the additions performed to compute the results of the remaining elements*, as demonstrated in Fig. 1:

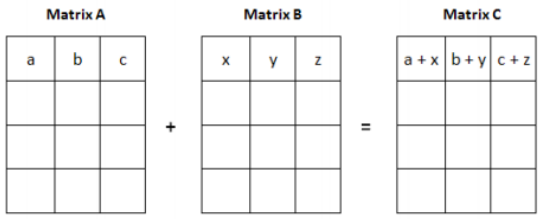


Fig. 1: Operations required for matrix addition

Theoretically, nothing prevents two operations from matrix addition from being executed at the same time, which is exactly what happens in practice when employing a parallel platform, where a distinct CPU is responsible for independently making each calculation and recording the result into memory [4].

A similar approach, although slightly more complex – due to the interconnected information that is required to gather and store (memory reads and memory writes), in terms of the matrix elements, as seen in Fig. 2:

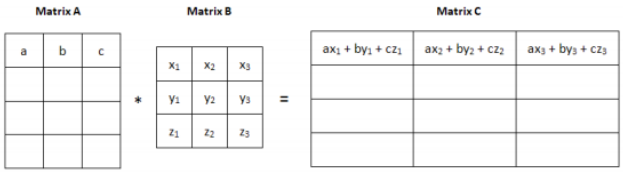


Fig. 2: Operations required for matrix multiplication

An element in row *i* column *j* in C is the sum of by-element products of row *i* from A and column *j* from B. Although in theory all elements in C can independently be calculated, for a large size matrix, even in multi-processor machines, there are not enough available processors to do all the necessary calculations in parallel. Instead, processors have to loop over the elements of the rows and columns of the matrices in order to produce the result of the multiplication. The following Fig. 3 is used to distinguish between the architecture of a CPU and a GPU:

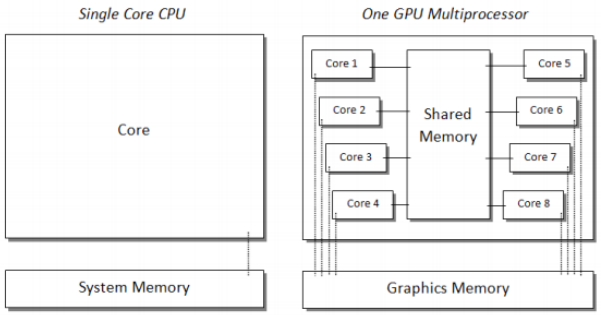
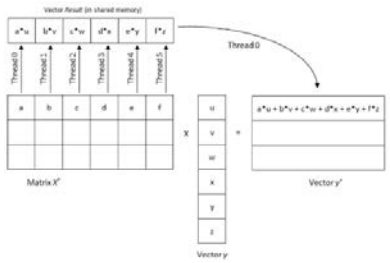


Fig. 3: Comparison betweenCPU / GPU architectures

When data is prepared for manipulation by the GPU, it is divided into blocks, which are then independently assigned for execution on one of the multiprocessors. Each block can have as many as 512 threads running simultaneously. Unless data is structured properly into blocks that are of size a multiple of a *warp* (32), a number of the threads in a warp may be inactive during a cycle, which is a drawback when the goal is maximum speed of execution. [3] However, there is still a great advantage in parallel calculations, such as matrix-vector multiplication, demonstrated in Fig. 4:



The speed-up of the multiplication for the first step, when done in parallel, as compared to a serial computation, will be the lesser of the two – the number of threads in a vCPU, or the width of the matrix (i.e. for a matrix that is 50 elements wide, we can expect a speed-up of 50x).

4.2 Bioisosterism by utilizing matrix functions and the GPU architecture

In conclusion, from the material presented in the previous sections, we can determine the importance of parallelism in bioisostere search algorithms – especially for molecules with complex structures. A rigorous analytical approach to examining bioisostere candidates by using any analytical descriptor (quantum wave-function electron field approach, symmetrical transformation approach, or other) could require trillions of linear algebra operations. The speed up of vector-matrix multiplication, matrix-matrix multiplication, and matrix inversion varies from 50-500x and above. To put this into perspective, any software that relies on the CPU for a specific bioisosteric algorithm (be it NERF or other), and takes one hour to deliver a full list of potential bioisosteres by utilizing the CPU, could deliver the same number of results in less than 10 seconds. When applying a “visual triage technique”- when the researcher needs to examine the bioisosteres visually, a difference between an 1-hour wait and a 10-second wait could prove to be of vast interest in making the process much more efficient.

Acknowledgments

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SCP-RPSC COHERENT TRANSPONDING SYSTEMS FOR IoT COMMUNICATIONS

SCP-RPSC ХОМОДИННИ СИСТЕМИ С ТРАНСПОНДЕРИ ЗА IoT КОМУНИКАЦИИ

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Abstract: *5th generation mobile networks, abbreviated 5G, are the proposed next telecommunications standards. 5G research and development also aims at improved support of machine to machine communication, also known as the Internet of Things, at millimeter waves. The move to these extremely high frequency bands, as well as the new requirements to the 5G network parameters, need new approach for the future technical systems solutions. One of those is the use of microwave coherent transponding system. Spatial Correlation Processing – Random Phase Spread Coding is a new technology in the field of microwave beam forming antenna theory, developed by the author one decade before. Its application in millimeter wave coherent transponding systems is proposed in this report. The system advantages are considered in details too.*

Keywords: 5 G, IoT, SCP, RPSC, MICROWAVE COHERENT TRANSPONDING SYSTEMS

1. Introduction

5th generation mobile networks or 5th generation wireless systems, abbreviated 5G, are the proposed next telecommunications standards beyond the current 4G/IMT-Advanced standards [1, 2]. Rather than faster peak Internet connection speeds, 5G planning aims at higher capacity than current 4G, allowing higher number of mobile broadband users per area unit, and allowing consumption of higher or unlimited data quantities in gigabyte per month and user. This would make it feasible for a large portion of the population to stream high-definition media many hours per day with their mobile devices, when out of reach of wi-fi hotspots. 5G research and development also aims at improved support of machine to machine communication, also known as the Internet of Things (IoT), aiming at lower cost, lower battery consumption and lower latency than 4G equipment.

There is currently no standard for 5G deployments. The Next Generation Mobile Networks Alliance defines the following requirements that a 5G standard should fulfill:

- Data rates of tens of megabits per second for tens of thousands of users;
- Data rates of 100 megabits per second for metropolitan areas;
- 1 Gbit/s simultaneously to many workers on the same office floor;
- Several hundreds of thousands of simultaneous connections for massive wireless sensor networks;
- Spectral efficiency significantly enhanced compared to 4G;
- Coverage improved;
- Signaling efficiency enhanced;
- 1ms Latency;
- Latency reduced significantly compared to LTE.

The Next Generation Mobile Networks Alliance feels that 5G should be rolled out by 2020 to meet business and consumer demands. In addition to providing simply faster speeds, they predict that 5G networks also will need to meet new use cases, such as the Internet of Things (Internet connected devices), as well as broadcast-like services and lifeline communication in times of natural disaster. Carriers, chipmakers, OEMS and OSATs, such as Advanced Semiconductor Engineering (ASE), have been gearing up for this next-generation (5G) wireless standard, as mobile systems and base stations will require new and faster application processors, basebands and RF devices.

Although updated standards that define capabilities beyond those defined in the current 4G standards are under consideration, those new capabilities have been grouped under the current ITU-T 4G standards. The U.S. Federal Communications Commission (FCC) approved the spectrum for 5G, including the 28 GHz, 37 GHz and 39 GHz bands, on July 14, 2016. The move to these extremely high frequency bands, as well as the new requirements to the 5G network parameters, need new approach for the future technical systems solutions. One of that is the microwave Coherent Transponding System (CTS) [3,4,5,6]. The system consists of interrogators and transponders (tags), operating at microwave ISM bands. The transponder does not generate any microwave carrier frequency itself but uses the received carrier power from the interrogator to send information back by simple passive processing, including phase or amplitude modulation and reflecting. The use of directional antennas in such systems at millimeter frequency bands will improve the functionality of CTS,s, as well as the frequency sharing situation.

SCP-RPSC (Spatial Correlation Processing – Random Phase Spread Coding) is an entirely new approach in the field of microwave beam forming antenna theory. It was developed by the author one decade before. The goal was solving the problems of the tracking microwave antenna systems for mobile satellite communications. The application of SCP-RPSC technology in CTS is proposed in this report. The system advantages are considered in details too.

2. Coherent transponding systems

The systems consist of interrogators and transponders (tags) operating at microwave ISM (Industrial, Scientific, Medicine) bands. The interrogator comprises a microwave transceiver using

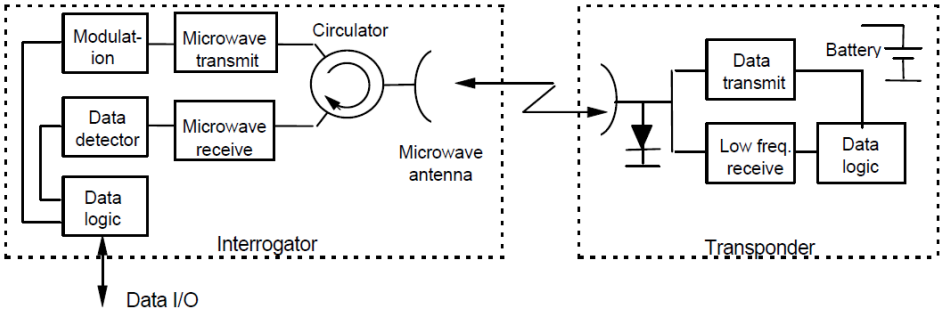

Fig. 1. *Block scheme of a CTS transponder and interrogator*

ASK (Amplitude Shift Keying) transmit and PSK (Phase Shift Keying) receive modulation. The transponder in its simplest form consists of a low frequency data receiver, data logic circuits, a low frequency data transmitter, battery for the circuits, microwave antenna and diode (figure 1) [5]. The interrogator transmitted ASK modulation is AM-detected by the transponder microwave diode, amplified, decoded by the data receiver and validated by the logic circuits. When the interrogator transmitter is unmodulated, the transponder is able to respond to the interrogator by modulating the received carrier and the modulated signal is then re-radiated from the transponder. As the transponder is without any essential RF selectivity the transponder can interrogate within a wide frequency range. To prevent unwanted interrogations the transponder may be designed with an access protocol for the specific application and/or a RF level threshold. However, this is not the case for all of the present systems. The transponder does not generate any microwave carrier frequency itself but uses the received carrier power from the interrogator. Consequently, within the bandwidth limits, the transponder will automatically track the interrogator frequency when used in a multi-channel or spread spectrum scheme.

By means of the formulas, given in [5,7,8], it is possible to derive the equation (1) for Power Link budget analysis of a CTS system:

$$(1)\quad E_b / N_0 = EIRP - 2L + G_r / T_s + 2G_{tag} + \\ + CL_{tag} + 228{,}6 - 10\lg R_b \quad \text{(dB)},$$

Where:

- E_b / N_0 (dB) is the Energy per Bit to Noise Density Ratio in the Interrogator receiver;
- $G_r / T_s = G_{rInt} - 10\lg T_{sInt}$ (dBi/K) is the Figure of Merit of the Interrogator Receiving System, G_{rInt} is the gain of the Interrogator receiving antenna, T_{sInt} is the Interrogator noise temperature;
- $EIRP = 10\lg P_{tInt} + G_{tInt}$ (dBW), is the Equivalent Isotropically Radiated Power of the Interrogator, P_{tInt} is the transmitted Interrogator power and G_{tInt} is the gain of the transmitted Interrogator antenna;
- $L = 20\lg R + 20\lg f + 92{,}45$ (dB) is the Free Space Path Loss, R is the distance between the Interrogator and the Transponder in km and f is the frequency in GHz;
- G_{tag} (dB) is Transponder (= tag) antenna gain;
- CL_{tag} (dB) is Transponder (= tag) conversion loss;
- R_b (bit/s) is the rate of the information in bit/s.

The estimated different classes and working distances R [5] for R_b = 10 kbit/s; 100 kbit/s and 1 Mbit/s in 2,45 GHz band are as follows:

- Class I: EIRP - 10 mW - 11 m, 6 m and 3 m;
- Class IIa2: EIRP - 100 mW - 18 m, 10 m and 6 m;
- Class IIb2: EIRP - 500 mW - 27 m, 15 m and 9 m.

Consider eq.(1) for the case when the working frequency is shifted up from f_1 to f_2 and the system parameters remain constant, which is not exactly true for the system noise temperatures and device losses:

$$(2)\quad E_b / N_0(f_1) = E_b / N_0(f_2)$$

Which leads to eq. (3), where the indexes (1) and (2) correspond to the frequencies f_1 and f_2:

$$(3)\quad G_{tInt1} - 40\lg f_1 + G_{rInt1} + 2G_{tag1} = \\ = G_{tInt2} - 40\lg f_2 + G_{rInt2} + 2G_{tag2}$$

Considering eq.(3) we can conclude, that the increasing of the working frequency, resp. the free space losses, could be compensated successfully by increasing the gain of the used antennas. It is well known from the theory, that the high gain antennas have directional beams. The last leads to necessity of scanning antenna beams in the case of mobile communication environment. The use of directional antennas will improve the functionality of CTS,s, as well as the frequency sharing situation. Different Multiple Access schemes could be used in order to increase Interrogator – multiple Transponders communication traffic capacity [6] (Fig.2).

3. *Possible SCP-RPSC coherent transponding systems*

3.1. *Introduction of SCP-RPSC approach*

The SCP-RPSC is an entirely new approach in the field of microwave beam forming antenna theory, developed by the author one decade before. The goal was solving the problems of the tracking microwave antenna systems for mobile satellite communications. First it was studied in receive mode (SCP technology) [9, 10], where its main objectives include:

- Receiving one or more radio signals coming from one or several spatially distributed sources (satellites), insuring high gain of the antenna systems and using fixed or mobile receiving terminals, equipped with SCP signal processing systems;

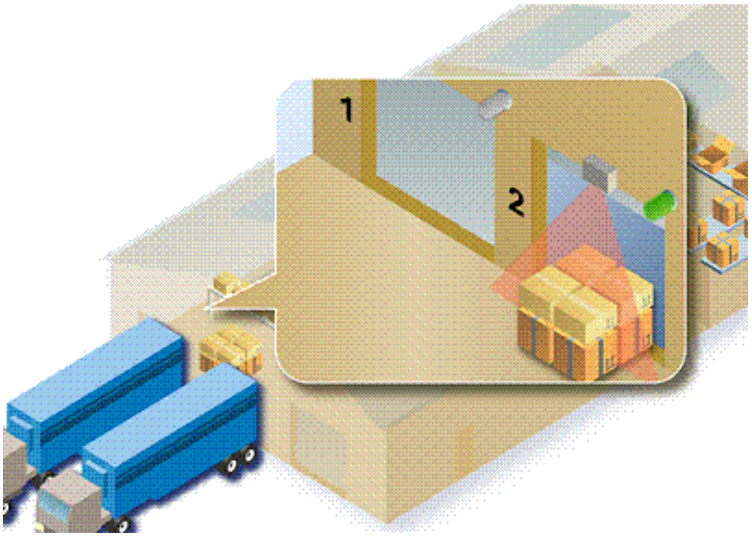

Fig. 2. *Confirming shipping contents*

- Insuring spatial selectivity high enough to cancel the same frequency channel interference, coming from different space directions, using simple one-channel receiver and patented signal processing principle.

The main features of the SCP approach are:

- Simple and cheap passive Radial Line Slot Antenna (RLSA), suitable for mass production in Ku and Ka frequency bands;
- One channel microwave receiver with simple signal processing;
- Omnidirectional for the cooperative satellite, but with high figure of merit G/T;
- Selection of different satellites and polarizations by PN-codes;
- Soft handover and virtual multi-beam features;
- Receive only system, but with possible applications in transmitting systems too;
- Applications in existing Digital Video Broadcasting – Satellite (DVB-S) systems with minor modifications of the ground transmitters, compatible with the existing satellite transponders.

The transmit mode (RPSC technology) [11,12] is based on transmission of broadband microwave signals in the open space by means of multi element random phased antenna arrays. The sum of the different elements signals in a given point in the space has Gaussian probability distribution and noise like properties. The sums in the different directions of the space are not correlated each other. In such way the proposed principle solves simultaneous the problems of signal spreading and beam forming of the future sophisticated microwave terrestrial and satellite communication systems with fixed and mobile applications.

The main features of the RPSC technology, when it is used in the up-links of the satellite communication links, additionally include:

- Omnidirectional for the cooperative satellite, but with high equivalent (at base-band) Equivalent Isotropic Radiated Power (EIRP);
- Selection of different terminals and polarizations by Pseudo-Noise (PN) codes;
- Soft handover and virtual multi-beam features;
- The coherent demodulation by means of pilots (specific property of SCP technology) cancels the Doppler shifts and phase jitter, introduced by local oscillators in the satellite system;
- Compatible with the existing bent-pipe satellite transponders;
- Providing of full duplex radiocommunication system with one simple and cheap transmit-receive antenna, using combined SCP-RPSC technology in both directions, particularly in Ku band;
- The transmitted random poly-phase spread signals will not cause significant harmful interference to the conventional satellites, using the same frequency channels. The interference will be similar to that, caused by the sidelobes of an antenna array with random elements distribution and main lobe, phased in another direction;
- RPSC up-links are protected against jamming, coming even from points, close situated to the earth stations – in the main lobe of the satellite up-link receiving antenna;
- The transmitted random poly-phase spread signals have low power spectral density and low detection probability for the conventional microwave receivers, leading to low active jamming probability.

In this report the "magic" properties of the SCP-RPSC technology, applied in the future sophisticated CTS,s, will be discussed in details.

3.2. SCP in the Interrogator

The application of SCP in the CTS Interrogator (SCP-I CTS) suggests that:

$G_{tInt1} = G_{tInt2}$ and $G_{tag1} = G_{tag2}$ in eq.(3) , which leads to:

(4) $G_{rInt2} = G_{rInt1} + 40 \lg f_2 / f_1$

For example if $f_1 = 2{,}45GHz$ and $f_2 = 24{,}125GHz$ (standard ISM frequency bands) the receiving Interrogator antenna gain should be increased with about 40 dB for the higher frequency band. A 30 cm in diameter SCP antenna has about 36 dBi gain, so the compensation is good, but not complete. Another additional advantage of a SCP-I CTS is the possibility to resolve different several Transponders, spatially distributed at angles, higher than the zero beam with of the SCCF (Spatial Cross Correlation Function) [10]. In such case Space Division Multiple Access (SDMA)

approach could be realized. For the particular values of the example this resolution angle is about 3 degrees.

3.3. SCP-RPSC in the Interrogator

The application of SCP-RPSC in the CTS Interrogator (SCP-RPSC-I CTS) suggests that:

$G_{tInt} = G_{rInt} = G_{Int}$ and $G_{tag1} = G_{tag2}$ in eq.(3) , which leads to:

$$G_{Int2} = G_{Int1} + 20\lg f_2 / f_1 \quad (5)$$

For example if $f_1 = 2{,}45GHz$ and $f_2 = 24{,}125GHz$ the transmit-receive antenna gain of the Interrogator should to be increased with about 20 dB. A 30 cm in diameter SCP-RPSC antenna at frequency f_2 has about 36 dBi gain in one direction, so the compensation is excellent. Another additional advantage is the possibility to resolve different several spatially distributed Transponders. The angular resolution is better than the previous case, but should be studied additionally in details.

3.4. SCP-RPSC in the Transponder

The application of SCP-RPSC in the CTS Transponder (SCP-RPSC-T CTS) suggests that:

$G_{tInt1} = G_{tInt2}$ and $G_{rInt1} = G_{rInt2}$ in eq.(3) , which leads to:

$$G_{tag2} = G_{tag1} + 20\lg f_2 / f_1 \quad (6)$$

For this particular example the transmit-receive antenna gain of the Transponder should be increased with about 20 dB and in the case of the use of 30 cm in diameter SCP antenna the compensation is excellent. The resolving of the different Transponders could be done by means of Random Phase Spread Coding - Multiple Access (RPSC-MA) approach [11].

3.5. SCP-RPSC in the Interrogator and the Transponder

The application of SCP-RPSC both in the CTS Interrogator and Transponder (SCP-RPSC-IT CTS) seems to be possible. This particular case, which promises many advantages, should be studied in details in the future.

4. Conclusions

An author proposal, dealing with possible application of SCP-RPSC technology in the next generations microwave Coherent Transponding Systems for 5 G IoT communications, is given in the report. The analyses shows very wide area of the different SCP-RPSC applications in CTS, when it is necessary to:

- Direct a narrow beam over a sector angle and give coverage like a sector antenna for Space Division Multiple Access of several Transponders;
- Obtain high antenna gains for the used Interrogators and Transponders in order to compensate the increased propagation losses at millimetre wavelengths;
- Narrow the antenna beam width in order to reduce multipath propagation problems;
- Create complex and dynamically re-configurable IoT radio networks exhibiting high spectrum efficiency;
- Reuse the frequencies and timeslots, using RPSC-MA;
- Obtain secure and reliable IoT government communications, resistive to enemy active jamming;
- Use “multiple spot beams” approach from unstable or mobile IoT platforms.

The practical SCP-RPSC principles implementations in millimetre wave CTS will solve successfully many of the existing problems of the future sophisticated 5 G IoT communications.

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BIOMASS AND WASTE WATER AS SUSTAINABLE ENERGY SOURCES

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Abstract: *Limited non-renewable resources and growing problems related to the protection of the environment are main reasons why renewable energy sources are used more and more. This paper presents compared technical and economic analyse of two renewable energy resources, biomass and waste water, for sanitary hot water preparation (DHW). Waste water (sewage) is a source of energy which can be used for heating and cooling buildings with heat pumps. The average waste water temperature such as found in restaurants, laundries, dormitories and etc. varies in the range of 20–40 °C through the whole year. The technology is simple and proven. Biomass as a renewable source of energy has the potential to offer a cost-effective and low carbon alternative to fossil fuels. It is considered as the renewable energy source with the highest potential to contribute to the energy needs of modern society for both the industrialized and developing countries worldwide. Renewable technologies are considered as clean sources of energy and optimal use of these resources are sustainable based on current and future economic and social needs. Compared analyse of the systems is applied for public institution „Home for male children and youth with disabilities" Prijedor, Bosnia and Herzegovina. Currently, this institution use light fuel oil and elektricity for their energy needs. The aim of this paper is to provide specific information about technology, economics and potential savings.*

Keywords: WASTE WATER, BIOMASS, HEAT PUMP, CLEAN SOURCES, RENEWABLE ENERGY SOURCES, ECONOMICS, ENVIRONMENT, SUSTAINABLE DEVELOPMENT

1. Introduction

In the past two centuries, the world has undergone a drastic change due to the steeply increased contribution of fossil fuels. Global population growth, expansion of economies, and higher standards have caused an enormous increase in worldwide energy consumption, which was partly made possible by the supply of cheap fossil fuels. Currently, fossil fuels such as oil, coal and natural gas represent the prime energy sources in the world (approximately 80% of the total use of more than 400 EJ per year) [1]. According to the projections, if the adequate policy initiatives are provided in 2025, 30% of the direct fuel use and 60% of global electricity supplies would be met by renewable energy sources [2].

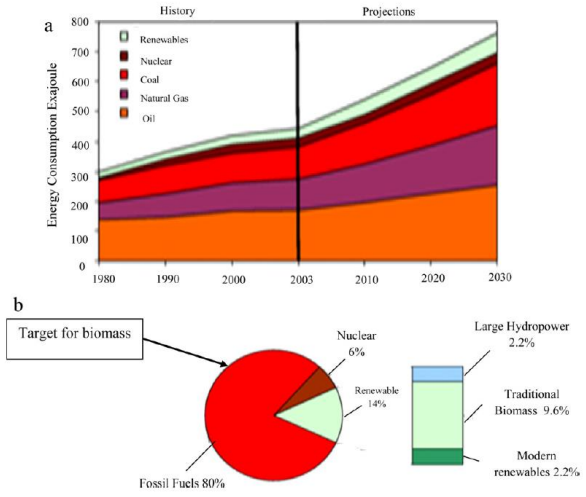

Fig.1(a) World marketed energy consumption. (b) Different fuels contribution to total world energy consumption [1]

Fossil fuel utilization puts pressure on our global ecosystem by contributing to global warming and harmful emissions. Moreover, the reserves of fossil fuels are finite. There are three ways to deal with this global challenge, and they all require drastic innovation development in the respective technologies:

• The energy efficiency of conversion systems should be drastically improved, going hand in hand with reduced use (savings);

• Renewable energy sources should be used in order to supply nonfossil-based energy.

Clean use of fossil fuels also will be needed for several decades to come, including carbon capture and storage (CCS).

The principle of these three energy utilization strategies is also called the "Trias Energetica," as illustrated by Figure 2.

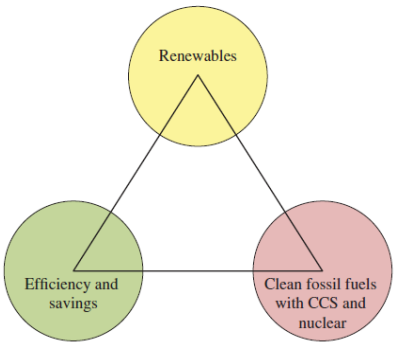

Fig 2. Concept of the "Trias Energetica," [3]

Continuous increase of energy prices from one side and need to ensure energy supply and comfort of the buildings from the other, gives complicates assignments to the engineers who are in position to combine different kinds of measures and approaches in order to get optimal solutions for certain type of the building. Basic principles of the sustainable energy supply systems are based on combination of the energy efficiency measures with renewable energy sources on a way which leads to the cost reduction as well as reduction of the harmful impacts on the environment. The aim of this paper was to determine the possibility of using waste water and biomass as a renewable energy sources for DHW preparation and its environmental impact, as well.

2. Waste water and biomass as renewable energy sources

Ever since the dawn of mankind, people have been using wood and other biogenic sources for heating, cooking, and lighting. Biomass consists of material that has an organic origin. That is plant and animal materials such as wood from forests, crops, seaweed, animal waste, material left over from agricultural and forestry processes. In the broader sense, all conversion products such as paper or cellulose, organic residuals from the food industry, and organic waste from households, trade, and industry. The sun's energy when intercepted by plants and converted by the process of

photosynthesis into chemical energy, is 'fixed' or stored in the form of terrestrial and aquatic vegetation. After coal and oil, biomass stands as the third-largest energy resource in the world [4]. Positive aspect of biomass as renewable energy source are:

- Biomass is abundantly available stored solar energy, which is thus indirectly used.
- Biomass is the only renewable energy source that can be coprocessed with fossil fuels in existing energy conversion systems (such as oil refineries or coal gasification plants) so as to ensure a gradual energy transition to a renewable energy source.
- As biomass is formed (indirectly) on a relatively short time scale via photosynthesis from CO2 and water, which are released again in energy conversion systems, in theory, one can speak of a "carbon-neutral" fuel.
- Biomass is already grown for food, animal feed, and natural fiber applications as well as in forestry with its derived products; it is comparatively easily accessible,and man has experience in dealing with this source.
- Biomass growing, harvesting, storage and transportation, trading, and processing to end use for energy conversion purposes can enhance rural economic development via the creation of additional jobs. This leads to extra income for rural regions of both developed and developing countries and eventually offers a way to counteract the constant depopulation of such areas.

Critical issues associated with use of biomass are:

- Conversion of solar energy into biomass is generally low (of the order of 1%, depending on the species); this means that relatively large surfaces are needed to harvest sufficient material for application in energy conversion.
- Biomass is characterized by a low energy density compared to fossil fuels. This low density often make biomass material difficult to store, transport, and utilize.
- Issues with deforestation, associated with serious loss of biodiversity and carbon stock
- There is concern with respect to biomass usage for energy supply as it may compete with food production depending on the types of biomass and technologies used
- Widely different disciplines are involved in the successful implementation of the whole integrated chain from seeding to final conversion and use, ranging from policy development and logistics to chemical, process technology, and agricultural sciences; in this light, implementation of effective policies is complex as bioenergy policies might conflict with other existing environmental or economic policies. For other energy sources, often, the only key is the energy conversion technology, whereas for biomass the whole system is crucial
- Although biomass itself is renewable, during the whole life cycle, fossil fuels are commonly used to produce fertilizers and pesticides, grow and collect the plants, transport the harvested material, and, finally, upgrade it to an actual fuel. Therefore, biofuels still have a fossil carbon footprint to some extent.

Driven by rising demand the global production capacity for wood pellets has more than doubled over the past 10 years. Global production of pellets estimated at 6-7 million tons in 2006 rose to more than 14.3 million tons by 2010 [5].

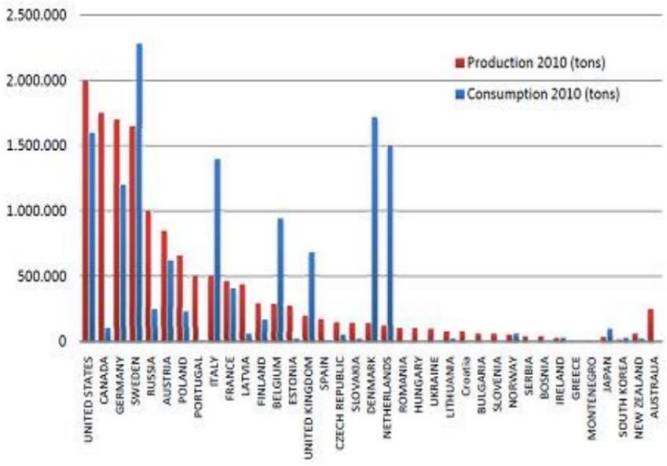

Fig.3 Wood pellet production and consumption by country in 2010 [6]

A "development which meets the needs of the present without compromising the ability for future generations to meet their own needs" has been a globally referred definition of sustainability. It was first characterized as such by the UN Brundtland Commission in 1987 (Brundtland, 1987). Figure 4 shows an overview of the economic, environmental, and social aspects that play a role in the sustainability of biomass supply systems.

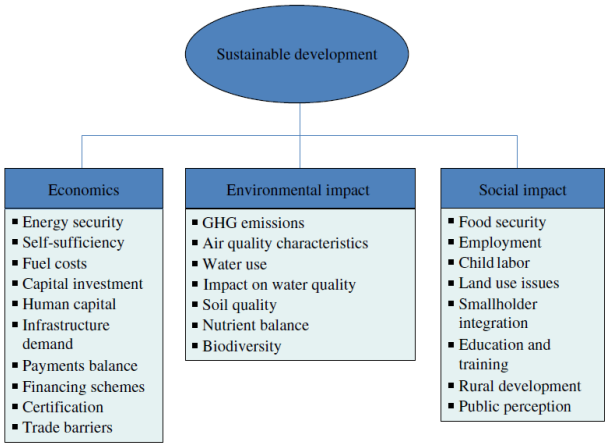

Fig 4. Aspects of sustainable development related to the implementation of biomass supply in society. [3]

The wood pellet market in Europe is currently thriving, predominantly driven by the EU 2020 target for renewable energy. Yet the European Union currently meets only around 4% of its energy needs through biomass. EU member states agreed to a binding 20% target for renewable energy in 2007 that includes 10% from biomass by 2020 as well as a 20% reduction in greenhouse gas emissions. Wood pellets are the most available form of biomass in the EU and this is why they have a crucial role to play in achieving the 2020 target [6]. According to Eurostat, Bosnia and Hercegovina exported 67,815 tons of pellets to the EU in 2012 and 170,389 tons in 2013 making an increase of 151% [6]. Therefore, during the last year Bosnia and Herzegovina surpassed Croatia, Ukraine and Belarus and became the second largest non-EU European exporter of pellets after Russia.

One of the renewable energy sources is also water discharged into sewage systems from households (different objects). Distribution of sewage water around the world has recently caused the increasing awareness of the amount of generated sewage water due to its large mass, the impact on the environment and energy potential. Sewage water is water used in residential areas and industries that have changed the physical, chemical and biological characteristics so can't be used in agriculture or other purposes. In calculating the amount of sewage from households, from 100% of

water from faucet, 70% water is discharged into the sewer and other 30% is irretrievably lost [7]. The average annual temperature of this water is 11 - 20.5 ° C which is sufficient temperature level to be used as a heat source for a heat pump [7]. Heat pump technology has been quickly developed all over the world as a clean and energy efficient heating and air conditioning mode, and it has been widely applied to apartments, houses, hospitals, office buildings etc.The main advantage of the usage of the heat pump is that design and operation conditions can be satisfied anywhere in the world. Waste water heat pump system was implemented for preparation of sanitary hot water in Student Center "Nikola Tesla" Banja Luka, Bosnia and Herzegovina. It's a first system of its kind in Bosnia and Herzegovina. As a basis for designing the system measurement of the temperature of waste water was made. Results are given at Fig 5.

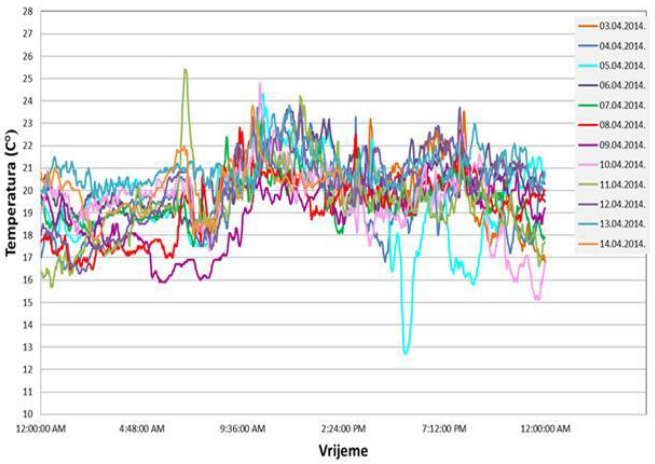

Fig 5. Waste water temperature in the period of measurement

As can be seen from the Fig.5, the temperature of the waste water fluctuates throughout the day. The highest values of temperature waste water are in period 8am-10pm and minimum are in period 11pm-5am. The highest measured temperature is 25.4 ° C and the lowest is 12.70 ° C. This measurments present basis for design of the system which is analyzed in this paper. Measurement shows that waste water has a high temeperature so it can be used as a source of energy for heat pumps. By integrating a heat pump to utilize this heat, it can be produced higher temperature supply while waste water is cooled and deprived to the sewer. This leads to the possibilitty of directly regenerating the hot water supply through wastewater heat recovery. Utilization of waste water as a source of energy for the heat pump for is analyzed by different researchers [8-13]. Similar systems are installed in other countries for example Schwitzerland and Norway [12]. In Japan and Korea, researchers did a simulation study of district cooling and heating systems using sewage water as an energy source [8]. Results show that compared with conventional air-source heat pumps, waste water heat pump could help reducing energy consumption by 34%, lowering the emission of carbon dioxide (CO2) by 68% and controlling the generation of nitrogen oxides (NOx) by 75% [8].
The most important characteristic of the heat pump is coefficient of performance (COP). The high and constant temperature of the heat source during operation is very important because it directly increases the COP and therefore operational costs of the heat pump decreases. The heat source must have a large capacity - to uniformly supply heat pump with energy. Based on the above mentioned, waste water as an energy source meets these two important conditions. Changing the flow for a period of 24 hours is determined by lifecycle of the population. Waste water is a finite source of energy. Available amount depends on the use of water in buildings. The possibilities for use that are economically interesting are concentrated at places where waste water is available both continuously and in large quantities. Those are buildings with large quantities of waste water such as hospitals, industry, student centers, restaurants, hotels, waste water treatment plants, etc. The quantity of waste water is increasing in countries with strong economic development and increasing standards of living. Energy from waste water is normally used to cover of constant loads; conventional back-up systems are used to meet peak loads. The use of waste water energy can further be subdivided into three categories depending on where the energy is extracted: a) energy recuperation in house (place where waste water is generated), b) energy recovery from sewers and c) energy recovery from cleansed wasre water at sewage treatment plant [12]. Recognition of waste water as a renewable energy leads to increasing stimulation of obtaining energy from it, create new jobs and a reduction in greenhouse gas emissions due to lower consumption of primary electricity which is basically derived from fossil fuels. Waste water as an energy source can be used as follows:

- anaerobic digestion for biogas,
- recovery of heat from waste water,
- different processes of conversion of energy from sewage water in other forms (pyrolysis, growing culture of algae, microbial fuel cells and other microbial conversion).

The economic vitality of the use of heat from sewage water depends on three crucial factors:

- the price of traditional energy sources
- the size of the system (the need for heat)
- the amount of sewage water.

Use of this renewable energy source reduces the use of primary sources (fossil fuels) which is a positive effect in protecting the environment. Since in many cases the wate water is discharged into rivers, and their average annual temperature is between 11 - 20.5 ° C, these waters contribute to the thermal pollution of the rivers. Whit increasing temperature and decrease of free oxygen in rivers, the effect of harmful substances in the water increases. For fish applies Van 't Hooff's rule that when temperature of water increase up to 10°C, chemical-physiological processes, in this case taking harmful substances, increases double or triple [14]. Discharge of cooled sewage water into rivers reduces thermal pollution and this is one more positive effect of using this energy source.

3. Compared analyze of waste water and biomass as a source of energy for DHW preparation system for public institution „Home for male children and youth with disabilities" Prijedor

The aim of this study was to determine the possibility of using waste water heat pump and biomass boiler as technical systems for DHW preparation in public institution „Home for male children and youth with disabilities" Prijedor, Bosnia and Herzegovina. Waste water heat pump system can be classified into two types:

- Using untreated waste water as heat source.This type of system is located close to the collector (sewers), but also close to the users Heat exchanger should be located between the sewer and water evaporator to avoid corrosion of evaporator. Quality of the sewage water has a significant influence on the corrosion on the supporting parts of the system (heat exchanger).

- Systems using treated waste water or neutral water as heat source. These systems have good water quality and are simple. Since sewage water treatment plant is generally at the verge of a city, it is far from heat consumers. If heat pump station is established in the sewage water treatment plant, the heating pipes would be very long and heat loss would be huge.

Waste water heat pump system which uses untreated waste water was analyzed. Accommodation capacity of the building is 200 people and it is fullfield through the whole year. Inside the building

is also a restaurant and a laundry. Demand for hot water is on daily basis and on large scale. Scheme of the system is given on Fig. 6. Waste water is collected in the collector, cooled and discharged into the sewer and temperature of water is low. Deprived heat of waste water is used in heat pump for the preparation of DHW.

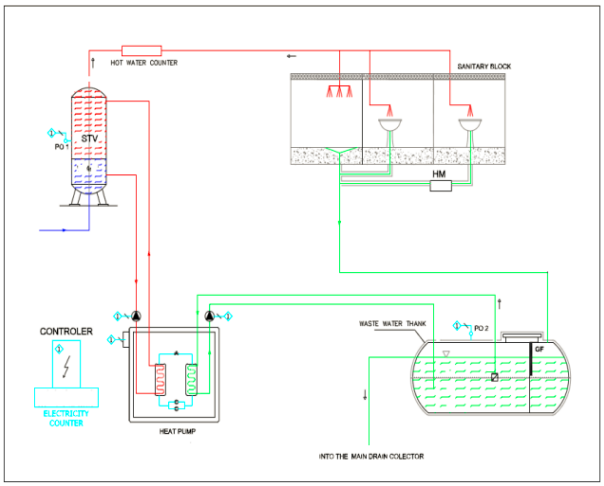

Fig. 6 Scheme of WWHP system

In order to calculate capacity of the system, temperature of waste water as a source of heat for heat pump, is very important. Waste water temperature which is used in calculations, is based on measurements for similar system where waste water was used as heat source for heat pump. As it's mentioned before in this paper, this system was implemented in Student centar "Nikola Tesla" Banja Luka. As both of buildings have same purpose, restaurant and laundry, assumption is that temperature of waste water is similar. Fig 5 shows results of measurements and average temperature for a whole period is 19.73 ºC. Required amount of a hot water for public institution „Home for male children and youth with disabilities" Prijedor is a base for the DHW system design. According to the literature [7], recommendation for the amount of hot water per capita is 60 l/day. Inside of this object is also a restaurant. Restaurant use approx. 300 l/day of hot water. The system is defined with the heat pump to the 23 kW heating capacity (water inlet temperature 12°C, heated water outlet temperature 50º C, freon R407 C). Calculating COP for this system is 3.12. Currently electric boilers are used for DHW so monthly bills are very high. The cost of annual energy consumption for the DHW is currently approx. 7300€. Compared to the WWHP system, system with woods biomass boiler is also analyzed. Wood pellets production is currently considered one of the most attractive investment opportunities in Bosnia and Herzegovina. Huge market demand in the neighboring EU market countries and the proven availability of the raw material are the key factors that drive investment opportunities in the production of wood pellets in Bosnia and Herzegovina. Due to that wood pellets prices are still low in Bosnia and Herzegovina, Republic of Srpska. Table 1 lists investment costs for both systems, estimated savings per year and payback period.

Table 1: Investment costs, savings per year and payback period for analyzed systems

	Investment cost [€]	Savings per year [€]	Payback period [years]
WWHP	23000	4980	5.76
Biomass boiler	1700	4430	> 1

As Table 1 shows, system which use biomass has lower investment costs then WWHP system. Savings per year are higher for WWHP system but payback period is less then one year for biomass system.

Fig 7 shows comparing annual operating costs of old and new systems. Waste water heat pump system has the lowest annual operating cost. This is due to the low electricity prices in Republic of Srpska. Biomass boiler system has annual costs also lower compared to the old system.

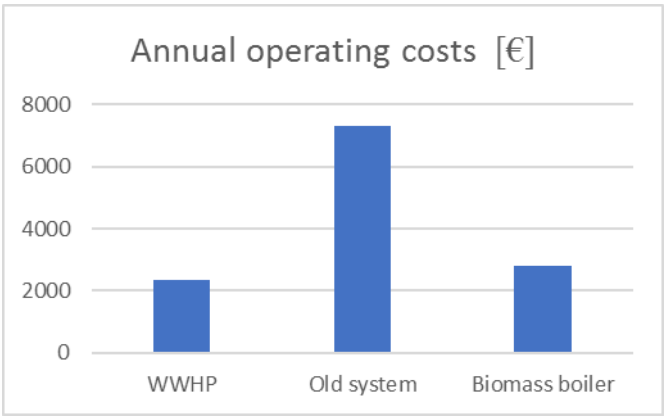

Fig. 7 Annual operating costs for new and old system

Figure 8 shows operating costs for a period of ten years for analyzed new systems and also a old one. As it's shown, old system has a biggest growth in operating costs through the years and wood biomass boiler has the smallest. If we consider that prices of electricity will grow in Bosnia and Herzegovina in the future, we can say that old system with electric boilers will have big trend of growth in operating costs.

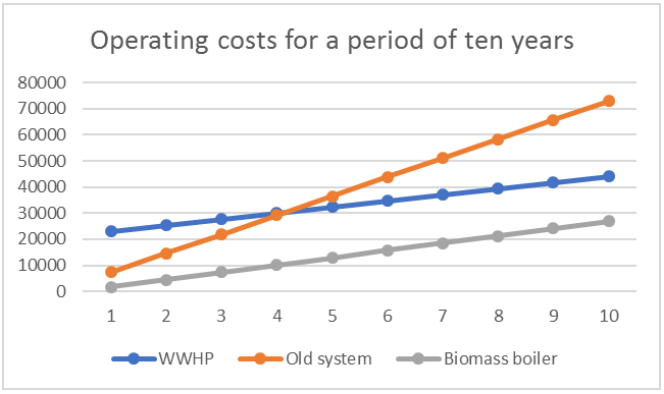

Fig. 8 Operating costs for a period of ten years

4. Conclusion

Renewable energy sources may significantly contribute to the protection of the environment from harmful emissions and costs reduction in the field of DHW production. Aim of this paper was to show how waste water and wood biomass as renewable sources can be used for DHW production for specific type of building such as public institution „Home for male children and youth with disabilities" Prijedor, Bosnia and Herzegovina. From technical point of view both sources are accepotable. Temperature of waste water is on high level so it can be used as heat source for heat pump. Heat pump is a simple and proven technology and uses a less primary energy then other systems. Duo to that its impact on environment is reduced. On the other hand, cooled waste water has less impact on rivers where in most cases goes. Biomass is one of the most available renewable sources in Bosna and Herzegovina, both economicaly and technicaly. It can be say that wood biomass has „zero emission" so this energy source is also acceptable in term of environment protection. Economic analyze showed that wood biomass is more justified source of energy than waste water. System with biomass boiler has lower investment costs and payback period less than one year. Waste water heat pump has bigger savings per

year then biomas boiler. Savings per year, for both systems, go up to 60%. All technical and economics aspects in this paper showed that these renewable sources should be used more and that can be one of the main keys in further sustanable development in Republic Srpska, Bosnia and Herzegovina.

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MINIATURE DEVICE FOR ENERGY CONVERSION – BASIC BUILDING ELEMENTS IN MECHATRONICS

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Abstract: A prototyping of miniature hyperboloid gear drives and ultrasonic motors is presented. A new type ultrasonic motor is experimentally tested.

Keywords: MECHATRONICS, HYPERBOLOID GEARS, ULTRASONIC MOTORS

1. Introduction

Mechatronics is the leading direction in contemporary industrial sciences and approach to the creation of products in the direction of synergistic integration of various branches of science and techniques as mechanics, electronics, electrical engineering, control theory and computer science.

This work has for objects of research *multibody systems mechanics*, which are mechatronics modulus. It contains a brief review of the development and improvement of the approaches for studying of the energy transformation processes, in order to achieve a regularly defined motions.

The multibody systems with force (regular) determined relations and interactions are developed in such way, so that they as a whole or separate bodies (body parts, respectively) of them to realize a law of energy transformation. In this case, the relations and interactions between bodies exist unlimited in time or duration of their existence is precisely defined. The predominant mechanical motions transformers and energy convertors and machines belong to these systems.

The *mechanical miniature multibody systems*, which purpose are to realize a preliminary defined law of energy transformation, which are the study objects are as follows:

- *miniature hyperboloid gear drives;*
- *miniature ultrasonic motor.*

2. Miniature Hyperboloid Gear Drives

2.1. Background

Typical products of mechatronics are bio-robots. Their transmissions as a rule include miniature transformers of motions and energy (see Fig. 1,a) [1, 2].

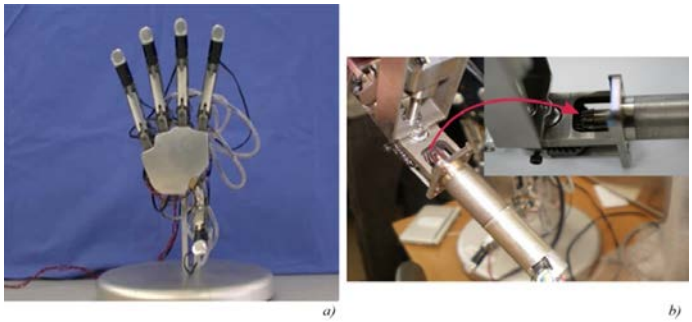
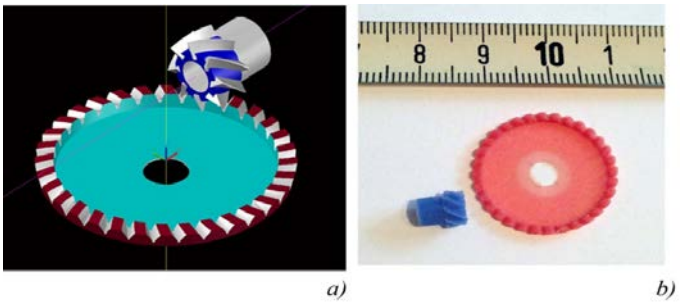


Fig. 1. *Model of robot hand: a) whole hand; b) bevel gear with straight teeth with* $i_{12} = 4$; $z_1 = 10$; $z_2 = 40$; $m = 0{,}5$ *mm*

The current work aims to present the realized by authors activates related with improvement of exploitation properties of the bio-robot hand shown on Fig. 1 [1 - 3]. The tasks related to the mentioned above goal is to find out a solution to the problems connected to the increment of the number of simultaneously contacting active tooth surfaces and also to create preconditions for controlling the backlash between mating gears which are implemented into the fingers of this hand. This is achieved when a plane bevel gear (Fig. 1b) is replaced with kinematically equivalent miniature spatial gear drive of type Spiroid or Helicon [3 - 5] (Spiroid and Helicon are registered trade mark of Illinois Tool Works, Chicago, Illinois.).

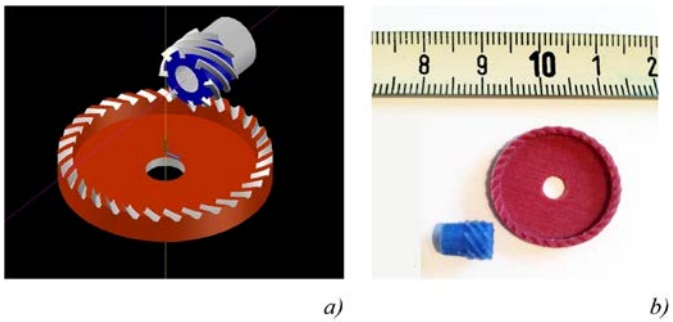
2.2. *Synthesis and Prototyping.*

The gear drives shown in Fig. 2 - Fig. 5 are specially synthesized by choosing the optimal structure and geometrical characteristics and they are CAD modelled. From an exploitation view point these gear drives are suitable for integration into already existing robot hand, which will result in its technical precision.



a) b)

Fig. 2. *Spiroid gear drive with offset 3,25 mm, gear ratio 32/8 (axial module 0. 5 mm): a) 3D CAD model; b) 3D printed model (the shown scale is in mm)*



a) b)

Fig. 3*. Helicon gear drive with offset 3,25 mm, gear ratio 32/8 (axial module 0. 5 mm): a) 3D CAD model; b) 3D printed model (the shown scale is in mm)*

The novelty of this design solution is that developed Helicon and Spiroid gears have a boundary small gear ratio. This is a

challenge both for their optimization synthesis and design in terms of their technical realization. The reason for this is that these gear pairs usually ensure rotations transformation with gear ratio more than 10 [6].

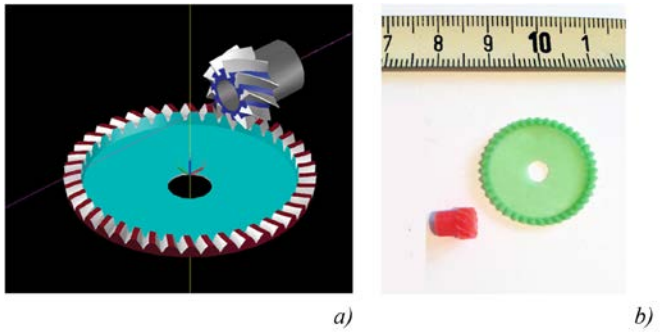


Fig. 4. *Spiroid gear drive with offset 4 mm, gear ratio 40/10 (axial module 0. 5 mm): a) 3D CAD model; b) 3D printed model (the shown scale is in mm)*

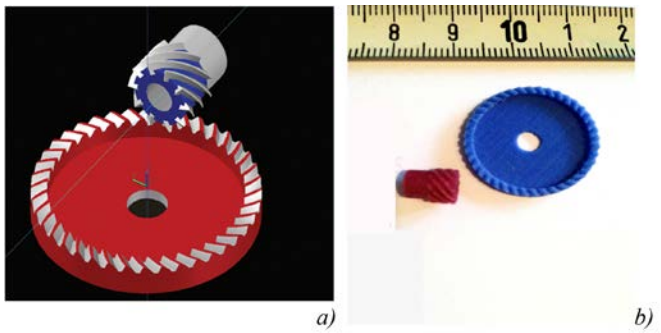


Fig. 5. *Helicon gear drive with offset 4 mm, gear ratio 40/10 (axial module 0. 5 mm): a) 3D CAD model; b) 3D printed model (the shown scale is in mm)*

The extreme difficulty of elaboration with available technical and technological device and the high manufacturing cost, define the reason to use 3D software technology for the elaboration of the above mention gear transmission (see Fig. 2 - Fig. 5).

We will mentioned, that the applied by authors, 3D software technology include the following stages:

- mathematical modeling for optimization synthesis of skew-axes gears upon a „pitch contact point“ [6, 7];
- development of a mathematical model for synthesis upon a „mesh region“[6] (development of a 3D CAD model);

- 3D printing of the synthesized gear drives.

Fig. - Fig. 5 illustrate the last two stages of the 3D software technology.

The use of this technology is a guarantee of :

- Shortening of the cycle "innovative idea - innovative product" ;
- Impetus of the innovative strategies development and increasing the actual quality of the created prototypes by improving their accuracy and a fast realization of various modifications (variants) of a physical prototype;
- Impetus to the process of building a competitive environment;
- Stimulation of the inventive and innovative activity of engineers, designers and scientists.

An essential problem, related to the 3D technology of manufacturing is the optimal choice of 3D printers and materials for the gear sets elaboration. The quality solution of these tasks is a guarantee for the optimal teeth strength, optimal smoothens and hardness of the active tooth surfaces.

2.3. Conclusion

The mathematical models of two Spiroid and Helicon gear drives for incorporation into the robot-hand are elaborated, based on the presented approach. An experimental printing with different alternatives material is forthcoming.

3. Miniature Ultrasonic Motor with a Metallic Plate

3.1. Background

Ultrasonic motor is a mechanical system for transforming an electric energy into a mechanical one. It is a type of electric motor powered by the ultrasonic vibration and friction of a component – the stator, placed against another component – the rotor or slider depending on the scheme of operation (rotation or linear translation). The ultrasonic vibration is generally generated by a piezoelectric element. The first applied in practice, ultrasonic motor is of a rotational type and it is developed in Japan in 1986 [8, 9]. Other motors with different working principle are elaborated after it, but in most cases it is difficult to be downsized [10 - 12].

This study presents a new miniature ultrasonic motor, which combines the operating of the ultrasonic motor with a metal plate [13]. The new ultrasonic motor is characterized with a simple construction, small dimensions and mass. The action of the created prototype is under testing.

3.2. Structure of the Motor.

In Fig. 6 are shown the device and basic dimensions of the stator of the new ultrasonic motor $(2{,}67mm \times 2{,}5mm \times 1{,}2mm)$. Stator's structure includes a piezoelectric element and a J-shaped metal plate. The piezoelectric element is a multilayer – type AM1 (with dimensions $1{,}2mm \times 1{,}2mm \times 2{,}47mm$) and it is elaborated by NEC/Tokin Corp., Japan. The material of the metal plate is phosphor bronze having a thickness of board $0{,}1mm$. Fig. 7 shows the result of the vibration mode by finite element method (FEM) analysis (the first frequency vibration mode is $4{,}7kHz$ and the second mode is $51{,}6kHz$). Through experiments it is verified the obtained rotation of the lowest frequency to high frequency.

The displacement characteristics are measured by the experiment. It is generated a 1 Hz trapezoidal wave from a function generator and it is applied as the driving signal by its amplifying with an amplifier. The horizontal displacement is detected by a laser sensor, and the data are recorded with an oscilloscope. When the voltage of $\pm 4V$ was applied, the maximum displacement was $0{,}26\mu m$ in the horizontal direction.

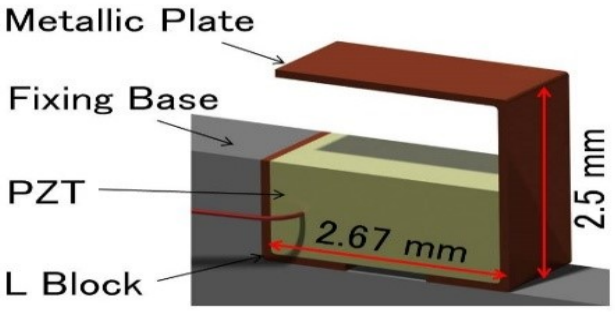


Fig. 6. *Structure of the stator*

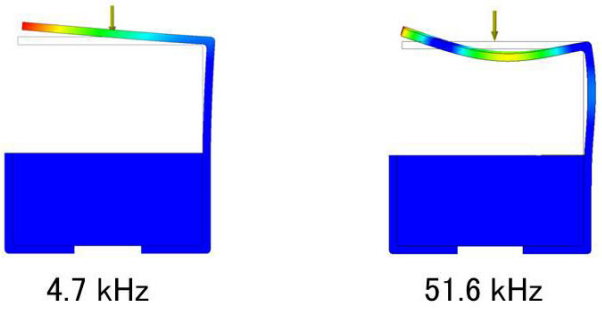


Fig. 7. *Vibrational modes of the stator*

3.3. Operating Principle

On Fig. 8 is shown the operating principle of the new ultrasonic motor. When a driving signal is inputted into the piezoelectric element, the voltage causes the piezoelectric element to stretch in horizontal direction. The extension drives the metallic plate. On Fig. 9 is shown a driving signal: (a) the driving wave for the rotation in the counterclockwise direction; (b) driving wave for the rotation in clockwise direction. The signal is saw-tooth shaped wave and the ratio of the voltage is 1: 8: 1 (see Fig. 9).

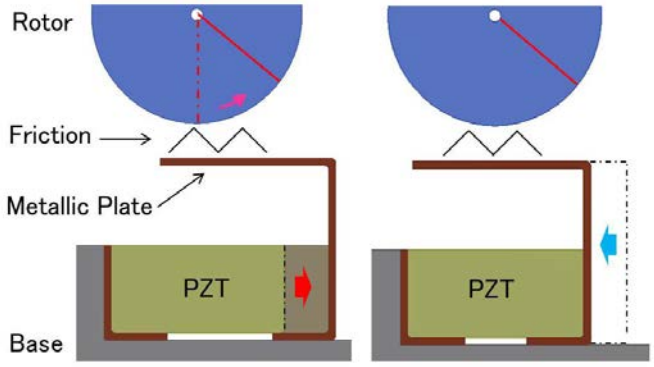


Fig. 8. *Operating principle*

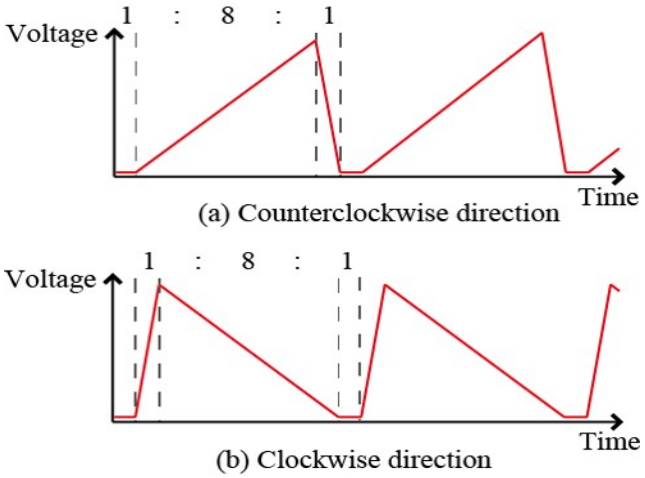


Fig. 9. *Driving wave*

3.4. Experiment

The equipment for the experiment is shown on Fig.10. A rotor is used to verify the rotation characteristics of the stator. The rotor has the miniature bearing with the diameter 3 mm which is made by the stainless. The video image is analyzed in order to measure the rotational speed. Since the bearing is so small, there are is not a measurement method.

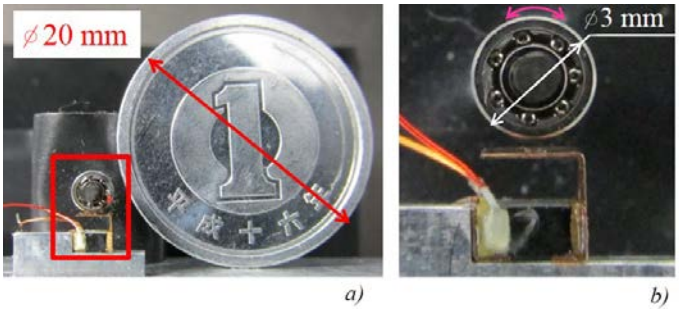


Fig. 10. *Experimental equipment: (a) Comparison of the size of the stator with a coin; (b) A miniature ultrasonic motor*

The conducted experiment is realized by changing the applied voltage to a piezoelectric element: $\pm 2V$; $\pm 3V$; $\pm 4V$. Fig. 11 shows the results from the experiment, when the rotor is rotating in clockwise direction. The vertical axis shows the rotor's rotational speed analyzed in the video image. It is found that when the driving frequency applied to the stator is higher, the resulting rotational speed of the rotor is higher. The maximum speed of rotation is around 360 min^{-1}, when the applied voltage is $\pm 4V$. The miniature motor has a rotation speed of 60-110 min^{-1} (by driving frequency of $85-175kHz$), and it can driven even with a very low voltage of $\pm 2V$.

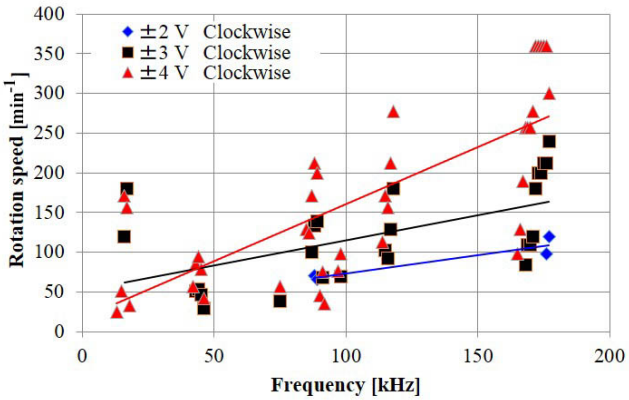


Fig. 11*. Results of the experimental test (rotation into clockwise direction)*

3.5. Conclusion

The study of new miniature ultrasonic motor is presented. Its structure combines multilayer piezoelectric element with a metal plate. It can realize a rotational speed of the rotor over 360 min^{-1}. The futures studies will examine the motor torque by using a force sensor.

4. Generalized Conclusion

The study is dedicated to the offered and applied by the authors of this work, two type miniature mechatronics modulus:

- miniature hyperboloid three-links transmissions with face mating gears of type Spiroid and Helicon, intended for incorporation into bio-robots;
- miniature ultrasonic motor with a driving metal plate, implanted in its stator;

The study contains information about the developed constructions, approaches to the synthesis, prototyping and experimental testing. The perspectives for the development of the created modules, as well as the possibility for their combining in order to establish a mechatronic systems, are declared.

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BALANCE CONTROL OF SEGWAY ROBOTS USING ADAPTIVE-ROBUST CONTROLLER

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Abstract: *Due to its compatibility and functionality, segways have been widely used in many countries. It was first introduced in December 2001.Yet, segway robots are faced with problems such as friction and external disturbances. Therefore, some controllers are designed to overcome with these problems. In previous studies, traditional controllers are used to balance a two-wheeled segway robot. The aim of this study is to minimize the trajectory tracking error. Due to external disturbances, such as wind, force and torque, robot parameters cannot be calculated exactly. Hence, the parameters of the robot are assumed to be unknown. In such situations, adaptive and robust controllers give better results. Adaptive and robust control laws were examined and adaptive-robust system was designed for the segway robot. Then Lyapunov function was defined and this adaptive-robust controller was derived from the Lyapunov function. And this control system applied to a two-wheeled segway robot model.*

Keywords: LYAPUNOV THEORY, ADAPTIVE CONTROL, ROBUST CONTROL

1. Introduction

In this study adaptive-robust and fuzzy logic controllers are developed for balancing Segway robot. There are lots of studies about balancing Segway robots.

Grepl [1], deals with the modelling and control of balanced wheeled autonomous mobile robot. In his study SimMechanics is used for modelling mobile robot. LQR and feedback linearization controllers are compared. Kim and Jung [2], used fuzzy logic control system for two-wheeled mobile robot. PID and fuzzy logic controllers are used to control both position and balance of two-wheel mobile robot. Performance of the PID and fuzzy logic controllers are compared through extensive experimental studies. Sangfeel, Eunji, KyungSik and ByungSeop [3], presented the fuzzy logic controller for inverted pendulum type mobile robot. They designed conventional fuzy logic controller. Chiu and Peng [4], designed fuzzy logic control system for two-wheel transporter control system. In their study, experimental results show that the fuzzy logic controller can control the whole system very well. Xu, Guo, and Lee [5], presented a Takagi–Sugeno-type fuzzy logic controller on a two-wheeled mobile robot. Their model consists of two wheels in parallel and an inverse pendulum. Finally, the results shows that fuzzy logic controller shows superior performance.

It is not easy to control inverted pendulum type systems because this type of system is a typical complex nonlinear systems. Kwak and Choi [6], designed two fuzzy logic control systems for the control of a Segway mobile robot. First they introduce the Segway robot and then analyze the system. Then they propose the design of two fuzzy logic control system for the position and balance control of the Segway mobile robot. A software fuzzy logic controller was implemented using a PIC microcontroller in Reid's [7] project. Hadiya, Rai, Sharma, More [8], describes the design and construct a fully functional two wheeled balancing vehicle. In this paper, the vehicle is designed for a single person. And the vehicle is driven by forward and backwards movements. Goher, Tokhi and Siddique [9], designed a two wheeled robotic vehicle with virtual payload. In this paper, two types of control techniques are developed and implemented on the system. They are proportional-derivative control and fuzzy logic control systems. Also an external disturbance force is applied to the road. Finally, the results are analyzed. Grasser, D'arrıgo, Colombı and Rufer [10], had built a prototype of a revolutionary two-wheeled vehicle. Two decoupled state space controllers are used to control the system.

In this paper, adaptive-robust and fuzzy logic controllers are developed for balancing Segway robot. First adaptive-robust control system is designed for the Segway model. The Segway is based on the principle of inverted pendulum that will keep an angle of Zero degrees with vertical at all times. Fuzzy logic control system is developed to keep the system in equilibrium. Then we introduce the two wheeled Segway robot and applied control laws to this model. Finally, results show that using adaptive-robust and fuzzy logic controller together, system gives better results.

2. Derivation of the Control Law

In the absence of friction or other disturbances, Spong writes the dynamic model of an n-link manipulator as [11];

$$M(q)\ddot{q} + C(q,\dot{q})\dot{q} + G(q) = \tau \tag{2.1}$$

where q denotes generalized coordinates, τ is the n-dimensional vector of applied torques (or forces), M(q) is the nxn symmetric positive definite inertia matrix, $C(q,\dot{q})\dot{q}$ is the n-dimensional vector of centripetal and Coriolis terms and G(q) is the n-dimensional vector of gravitational terms. Equation (2.1) can also be expressed in the following form.

$$Y(q,\dot{q},\ddot{q})\pi = \tau \tag{2.2}$$

where π is a p-dimensional vector of robot parameters and Y is an nxp matrix which is a function of joint position, velocity and acceleration. For any specific trajectory, the desired position, velocity and acceleration vectors are q_d, $\dot{q}_d$ and $\ddot{q}_d$. The measured actual position and velocity errors are $\tilde{q}=q-q_d$, and $\dot{\tilde{q}}=\dot{q}-\dot{q}_d$. Using the above information, the corrected desired velocity and acceleration vectors for nonlinearities and decoupling effects are proposed as:

$$\dot{q}_r = \dot{q}_d - \Lambda\tilde{q}\ ; \qquad \ddot{q}_r = \ddot{q}_d - \Lambda\dot{\tilde{q}} \tag{2.3}$$

Then, σ is given as [11];

$$\sigma = \dot{q} - \dot{q}_r = \dot{\tilde{q}} + \Lambda\tilde{q} \tag{2.4}$$

where Λ is a positive definite matrix. Then the following nominal control law is considered:

$$\begin{aligned}\tau_0 &= M_0(q)\ddot{q}_r + C_0(q,\dot{q})\dot{q}_r + G_0(q) - K\sigma \\ &= Y(q,\dot{q},\dot{q}_r,\ddot{q}_r)\,\pi_0 - K\sigma\end{aligned} \tag{2.5}$$

The control input τ can be defined in terms of the nominal control vector τ_0

$$\begin{aligned}\tau = \tau_0 + Y(q,\dot{q},\dot{q}_r,\ddot{q}_r)\,u &= M_0(q)\ddot{q}_r + C_0(q,\dot{q})\dot{q}_r + G_0(q) - K\sigma \\ &= Y(q,\dot{q},\dot{q}_r,\ddot{q}_r)\,(\pi_0 + u) - K\sigma\end{aligned} \tag{2.6}$$

where $\pi_0 \in R^p$ represents the nominal parameters in dynamic model and Kσ is the vector of PD action.

$$\tilde{\pi} = (\pi_0 - \pi) \le \rho \tag{2.7}$$

where $\rho \in R^p$, $\delta \in R$ are the upper uncertainty bound on the parametric uncertainty. Let us define the control input u

Theorem 1: [11]

$$u = \begin{cases} -\hat{\rho}\dfrac{Y^T\sigma}{\left\|Y^T\sigma\right\|} & \text{ve} \quad \left\|Y^T\sigma\right\| > \varepsilon \\ -\hat{\rho}^2\dfrac{Y^T\sigma}{\varepsilon} & \text{ve} \quad \left\|Y^T\sigma\right\| \le \varepsilon \end{cases} \tag{2.8}$$

The Lyapunov function candidate is defined as;[11]

$$V = \frac{1}{2}\sigma^T M(q)\sigma + \frac{1}{2}\tilde{q}^T \Lambda^T K \tilde{q} \tag{2.9}$$

$$V \ge 0$$

Derrivative of the Lyapunov function is:

$$\begin{aligned} \dot{V} &= -\dot{\tilde{q}}^T K \dot{\tilde{q}} - \tilde{q}^T \Lambda^T K \Lambda \tilde{q} + Y^T\theta(\tilde{\pi} + u) \\ &= -x^T Q x + Y^T\theta(\tilde{\pi} + u) \end{aligned} \tag{2.10}$$

Where $x^T = [\tilde{q}^T, \dot{\tilde{q}}^T]$ and $Q = \mathrm{diag}(\Lambda^T K \Lambda, K)$ the rest of the proof is given in [11].

$$\dot{V} \le 0 \quad \text{for} \quad \|x\| \rangle w \quad \text{where} \tag{2.11}$$

$$w^2 = \varepsilon\rho / 2\lambda_{min}(Q) \tag{2.12}$$

Where $\lambda_{min}(Q)$ denotes the minimum eigenvalue of Q. The argument proceeds as follows. Examining the second term in (2.10), we see that if then;[11]

$$\begin{aligned} Y^T\sigma(\tilde{\pi} + u) &= Y^T\sigma\left(\tilde{\pi} - \rho\frac{Y^T\sigma}{\left\|Y^T\sigma\right\|}\right) \\ &\le \left\|Y^T\sigma\right\|\left(\|\tilde{\pi}\| - \rho\right) \langle 0 \end{aligned} \tag{2.13}$$

from the Cauchy-Schwartz inequality $\left\|Y^T\sigma\right\| \rangle \varepsilon$ and our assumption on $\|\pi\|$. If $\left\|Y^T\sigma\right\| \le \varepsilon$ we have

$$\begin{aligned} Y^T\sigma(\tilde{\pi} + u) &\le Y^T\sigma\left(\rho\frac{Y^T\sigma}{\left\|Y^T\sigma\right\|} + u\right) \\ &\le Y^T\sigma\left(\rho\frac{Y^T\sigma}{\left\|Y^T\sigma\right\|} - \frac{\rho}{\varepsilon}Y^T\sigma\right) \end{aligned} \tag{2.14}$$

This last term achieves a maximum value of $\varepsilon\rho/2$ when $\left\|Y^T\sigma\right\| = \varepsilon/2$. Thus we have that

$$\dot{V} \le -x^T Q x + \varepsilon\rho/2 \tag{2.15}$$

To complete the proof, it suffices to notice the following. With class-K functions $\gamma_1(.)$ and $\gamma_2(.)$ such that

$$\gamma_1(\|x\|)I \le M(q) \le \gamma_2(\|x\|)I \tag{2.16}$$

it can be shown that there exist class-K functions $\alpha_1(.)$ and $\alpha_2(.)$ such that

$$\alpha_1(\|x\|) \le V \le \alpha_2(\|x\|) \tag{2.17}$$

Equation (2.15) shows that:

$$\dot{V} \le -\alpha_3\|x\|^2 + \varepsilon\rho/2 \tag{2.18}$$

3. Fuzzy Logic Controller

With fuzzy logic, like small, medium and large vague linguistic expressions can be expressed as by membership functions. These membership functions are triangular, trapezoidal or bell curved shape. (Fig. 1). They take the values between [0,1].

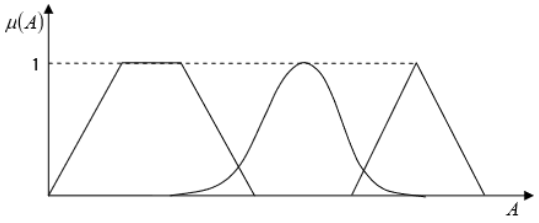

Fig. 1 *Different shapes of membership functions* [12]

Fuzzification, Rule Evaluation and Defuzzification are the steps of the fuzzy logic control. In the first stage, membership functions are defined for the variables. Thus, certain values are converted to fuzzy values. The second stage is the rule evaluation. The rules have been prepared based on the knowledge of the system. And the output of the system is decided by the input of the system.

Fuzzy Logic Controller has two inputs and one output. These are error of theta, it's derrivative and output is the control force respectively. Linguistic variables which implies inputs and outputs have been classified as: NB, NS, Z, PS, PB. Inputs and outputs are all normalized in the interval of [0, 1] as shown in Fig.2

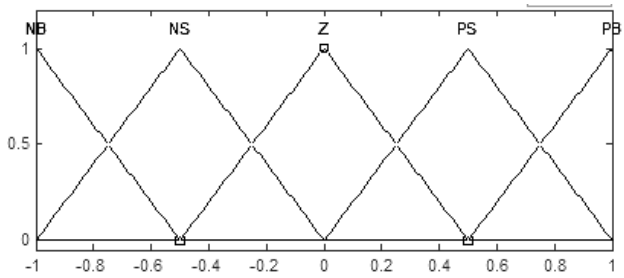

Fig. 2 *Membership functions of inputs (et, det) and output (u)*

The linguistic labels used to describe the Fuzzy sets were "Negative Big" (NB), "Negative Small" (NS), "Zero" (Z), "Positive Small" (PS), "Positive Big" (PB). Rules are written in a rule base look-up table which is shown in Table 1

Table 1: *Decision Table (et, det, u)*

etheta\detheta	NB	NS	Z	PS	PB
NB	NB	NB	NS	NS	Z
NS	NB	NS	NS	Z	PS
Z	NS	NS	Z	PS	PS
PS	NS	Z	PS	PS	PB
PB	Z	PS	PS	PB	PB

4. Equations of Motion

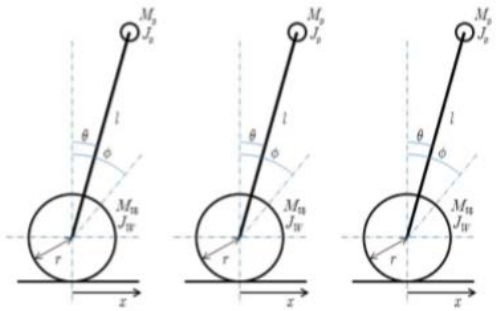

Fig. 3 *Schematics of Segway type mobile robot. [6]*

$$\begin{aligned} M_w\ddot{x} &= H+H_w \\ J_w\ddot{\phi} &= -rH_w + \tau \end{aligned} \tag{4.1}$$

The rotational angle of the wheel and the displacement of the robot have the following relationship:[6]

$$r\ddot{\phi}=\ddot{x} \tag{4.2}$$

From Eqs. (4.1) and (4.2), the dynamic equations of the Segway robot are; [6]

$$(M_w + M_p + \frac{J_w}{r^2})\ddot{x} + M_p l\cos\theta\ddot{\theta} - M_p l\sin\theta\dot{\theta}^2 = \frac{\tau}{r} \tag{4.3}$$

$$(J_p + M_p l^2)\ddot{\theta} + M_p l\ddot{x}\cos\theta - M_p gl\sin\theta = -\tau \tag{4.4}$$

where M_w is mass of wheel, J_w is the inertia of wheel, θ : Angle of pole, x is displacement of the robot, r: radius of wheel, M_p :Mass of center of gravity of pole, J_p Moment of inertia of center of gravity of pole and ϕ : Rotational angle of wheel.

Also the torques are represented in a matrix form like in (4.5)

$$\tau = \begin{bmatrix} M_{11} & M_{12} \\ M_{21} & M_{22} \end{bmatrix}\begin{bmatrix} \ddot{x} \\ \ddot{\theta} \end{bmatrix} + \begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix}\begin{bmatrix} \dot{x} \\ \dot{\theta} \end{bmatrix} + \begin{bmatrix} G_{11} \\ G_{21} \end{bmatrix}\begin{bmatrix} x \\ \theta \end{bmatrix} \tag{4.5}$$

This new control law applied to two wheeled segway robot. Simulations have been done by using control law (2.8). We simulate the position and balance control of the Segway mobile robot using adaptive-robust and fuzzy logic controller together. The results of the angle of the pole, the angle error of the pole, the displacement, the change in the displacement are shown in Figures 4, 5, 6 and 7 respectively.

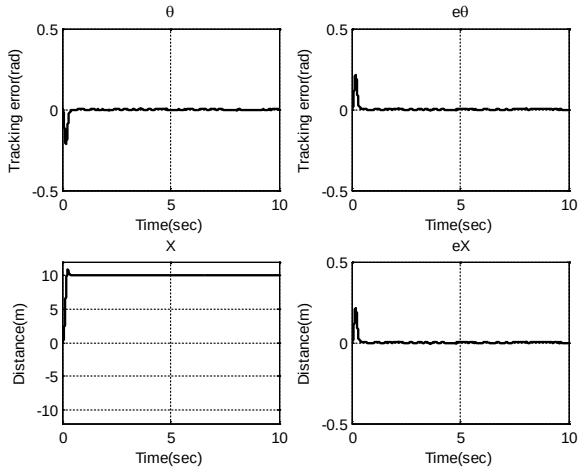

Fig. 4 *Response using the adaptive-robust and fuzzy logic control law when Λ=diag(20 20), K=diag(20 20). The target position is 10 [m].*

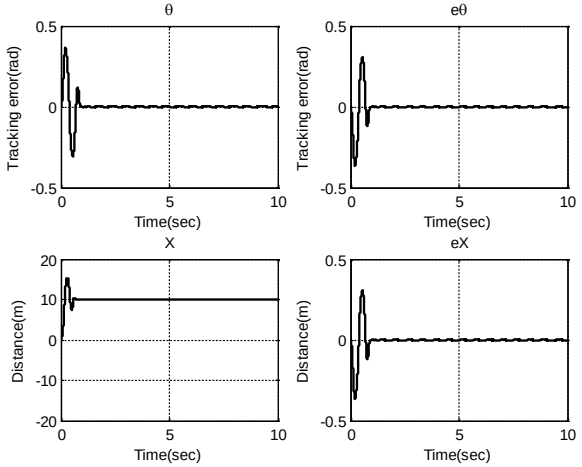

Fig. 5 *Response using the adaptive-robust and fuzzy logic control law when Λ=diag(50 50), K=diag(50 50), The target position is 10 [m].*

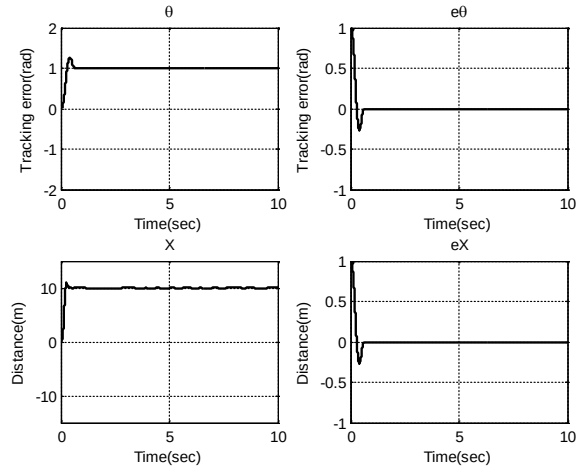

Fig. 6 *Response using the adaptive-robust and fuzzy logic control law when Λ=diag(20 20), K=diag(20 20), The target position is 10 [m]. The reference rod is 1 rad.*

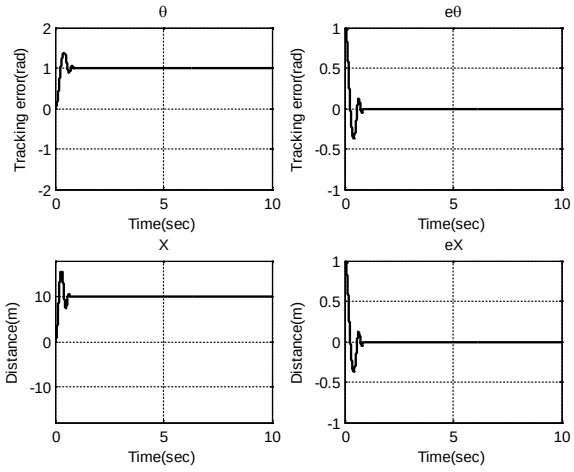

Fig. 7 *Response using the adaptive-robust and fuzzy logic control law when Λ=diag(50 50), K=diag(50 50), The target position is 10 [m]. The reference rod is 1 rad.*

5. Conclusion

The aim of this study is to develop a novel fuzzy logic control and adaptive-robust control law to minimize the trajectory tracking error and balance the rod. We develop adaptive-robust controller for position control then we design fuzzy logic controller for balancing

the rod. As seen in the figures 4 - 7, the optimal values for K and Λ system gives better results. The main important part of this study is the parameters of robot are assumed to be unknown.

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APPENDIX

$$M_{11} = M_w + M_p + \frac{J_w}{r^2}$$
$$M_{12} = M_{21} = M_p l\cos\theta$$
$$M_{22} = J_p + M_p l^2$$

$$C_{11} = C_{21} = C_{22} = 0$$
$$C_{12} = -M_p l\sin\theta\dot{\theta}$$

$$G_{11} = C_{12} = C_{21} = 0$$
$$G_{22} = -M_p gl$$

And some parameters of the Segway mobile robot are as follows:[13]

$$M_w = 0.076\text{kg}$$
$$J_w = 3.42\text{x}10^{-5}\text{kgm}^2$$
$$M_p = 0.6\text{kg}$$
$$J_p = 1.34\text{x}10^{-2}\text{kgm}^2$$
$$g = 9.81\text{m/s}^2$$
$$r = 0.03\text{m}$$
$$l = 0.15\text{m}$$

$$M = \begin{bmatrix} \pi_1 & \pi_2 \\ -\pi_2 & -\pi_3 c_2 \end{bmatrix}\begin{bmatrix} \ddot{x} \\ \ddot{\theta} \end{bmatrix}$$
$$C = \begin{bmatrix} 0 & \pi_3 s\theta\dot{\theta} \\ 0 & 0 \end{bmatrix}\begin{bmatrix} \dot{x} \\ \dot{\theta} \end{bmatrix}$$
$$G = \begin{bmatrix} 0 \\ \pi_4 \end{bmatrix}\begin{bmatrix} x \\ \theta \end{bmatrix}$$

$$\pi_1 = (M_w + M_p + \frac{J_w}{r^2}) \qquad \pi_2 = M_p l$$
$$\pi_3 = J_p + M_p l^2 \qquad \pi_4 = M_p gl$$

THE HUMAN CAPITAL RATIFICATION – A KEY FACTOR FOR DEVELOPMENT

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Abstract: *The maturing of markets and market relations lead to increased competiveness and consumer's requirements as well as transform the quality as a factor of company's success and survival. Increasing the human resource quality through using and applying appropriate methods and technics contributes to the organization stability. The human resources transformation into human capital is a basic condition for development of the enterprises. The survey is based upon own questionnaire through the employee in event management company. The results indicate that taking measures in accordance with the new good practices and motivation policies lead to positive changes and development of the company.*

Keywords: HUMAN CAPITAL, BUSINESS DEVELOPMENT, HUMAN RESOURCES, METHODS, TECHNICS, QUALITY

1. Introduction

The maturing of markets and market relations lead to increased competiveness and consumer's requirements as well as transform the quality as a factor of company's success and survival. The theme significance takes a central place in discussions, researches and organizational activities in the field of production and services. There is a rich elaboration of science and science – practical approaches in theories, standards, practices and systems for quality management. Increasing the human resource quality in strategic aspect helps to broaden the flexibility and enterprise's potential through their basic "asset" – the human resources.

The object of this survey is the employee in Event Company.

The subject of this report is introducing methods and technics for increasing the human resource quality and opportunities to be implemented in the organization.

The researcher's **thesis** is that the proper use and implementation of methods and technics for raising the employee's work quality is a basic condition to manage the strategic development as well as providing a company's competiveness through their employee.

The basic aim of this report is connected with argumentation the necessity of investment in people, gaining new knowledge and skills, a life-long learning, a comprehensive increase in their work quality as factors which lead to company's competitive development.

The quality management includes key elements in employee's activity, the inside relations, the interaction with the surroundings and the way of functioning focused to realize the enterprise's goals. In this survey are considered exact methods and technics which help for increasing the work quality.

2. Strategies, methods and technics for increasing the human resource quality

2.1. The strategy "life-long learning"

The observations indicate that the qualification level of Bulgarian manpower is related with a tendency to decrease, even to degradation. The basic reason for that is the emigration process through the years of the Bulgarian transition period of more than 1 million educated and qualified, mostly young people, which is a fatal mistake for the Bulgarian economy. That's why the enhancement quality of the human resources is a priority strategic problem for our country.

The life-long learning can be defined as every focused educative work which helps for continuous improvement of people's knowledge, abilities and competences. It's necessary to be created an interest both in employer and in employee for permanent qualification enhancement through a normative regulation; an exactingness and control in occupying a position by qualified candidates which provide achieving the expected results of the strategy "life-long learning". Indications for the lack of interest are the insufficient results of assimilated funds by the European program "Human resource development".

For a successful strategy implementation in the company is necessary to be created opportunities for certifying results of distant, informal and independent education, of practical skills and recognition of all education achievements – knowledge, skills, competencies. This will provide an opportunity for employee to combine the working obligations with learning. The holding of exam by the company's managers is frequently a wrong action because it creates tension in the organization. Much more productive is the method of practical usage of learning when the employee is implemented in different role games or case study. In this way the theory is put into practice and the education results are obvious and estimated by the employer.

The application of a strategy life-long learning leads to enhancement of human resource quality on the next fields:

- A sustainable and ascending company development because the permanent gathering of new knowledge, skills and competences make employee more productive and the enterprise – more competitive.

- A higher living standard, a better company culture, a bigger mobility and labor satisfaction.

- An increase devotion to the enterprise.

2.2. Methods for development and use of employee's creative potential

The comprehension of the entire potential of employee in the goal activity has a key importance in providing competitive advantages and creating high level organizational effectiveness. From a great matter is the developing and utilization of employee creative potential. By means of it are realized numbers of functions as:

- A participation in management of different levels in the organizational functioning. To the employee is given an opportunity to take the manager's position for a definite period (recommended for a week) and after that is analyzed his impressions, recommendations and conclusions about the company environment.

- Forming a communication network which provides the creation of a communication circle. This is a precondition for realizing a moving process of active communication streams top-downs and bottom-up as well as on a horizontal line.

- Realizing a process of training and self-training as the theoretical learning is made by the employee himself but the company provides the implementation of learning.

-Building of high motivation levels in the enterprise – raising the employee's motivation is a precondition for better labor results and quality of work.

For the effective use of employee's creative potential is recommended the creation of different inside organizational structures like:

- **Small groups for activity improvement** – they are created within the boundaries of basic lineal groups in every functional field. Their target is to assist the process of problem solving in different spheres – quality, prime cost, working environment, etc.

- **Activity for suggestions** – the orientation is toward formation a creative atmosphere that will give a chance of every employee to take part in problem solving in the organization.

- **Patrol groups** – particularly created employee groups on a rotational principle realize control and self-control on specific parameters in the working environment.

- **Intelligent groups** – the highest specialized form of creative participation and improvement orientated toward problem solving on a strategic level. Every employee has the opportunity to take part in the organized discussions and to give solutions.

2.3. Specific technics for employee's training

The economic globalization and its influence over the manpower necessitate more different way of training. The human force for improvement and change for the better are one of his fundamental characteristics. No matter the kind of activity and his way of life this desideration is a basic factor and determines the feeling of success and satisfaction.

The project method is created by J. Dewey and elaborated by U. Kilpatrick. According to this method the trainees work independently in small groups on a specific theme. The aim is not only to choose and solve an exact problem but the trainees to understand as much as its aspects which are organically connected with the exact problem in real life. Every project is unique and indefinite because the problems are not an abstract conception but are deduces by the reality. An important priority of the project method according to the traditional training is that the verbal activity is not so dominant but the accent is toward "learning through action" which is a characteristic element in training. Other priority is that the trainees with different skills take an equal participation in solving the problem they have chosen together.

The sociodrama is a dramatic play in which several individuals act out assigned roles for the purpose of studying and remedying problems in group or collective relationships. It was developed by social scientist Jacob L. Moreno to explore sociological interests using the techniques he originated in psychodrama for psychology. Sociodrama may be applied to collective trauma and current events, social problems and disintegration, prejudice, interpersonal tension and justice and rehabilitation. The basic idea is that a human can learn not only by gathering new information but also to restructure and redefine his own experience. It's considered that sociodrama can be useful in forming of social skills and models of behavior. Its base is the role and the identification. The aim is trainees to think about the problem using their own experience.

The casus is a method of independent knowledge implementation. Using this method the trainee's motivation increases and is presented the connection between economic science and the reality.

The role game simulates the reality and gives an opportunity to gather an experience for social behavior, to define, analyze and overcome an interest conflict, to take decisions. According to this are paid by working economic behavior, actions, obligations and functions of the separate person.

3. An empiric survey of the opportunities for increasing the human resource quality

Aiming the successful management of an object is necessary to know its characteristics. This is valid including this research connected with the human resource quality. The survey is made in a service sector company with basic activity Event planning. All the employee take part in the survey (60 employees) and is used own questionnaire with 18 questions.

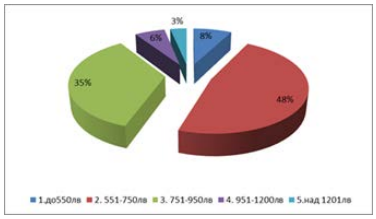


Fig. 1 *Basic salary*

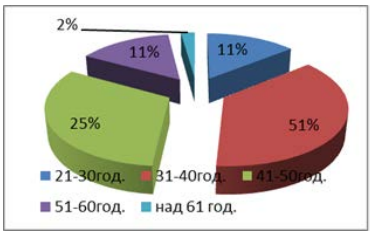


Fig. 2 *Employee's age*

Fig.3 *Manager's influence over the work quality*

The manager's actions through commands and orders have a strong influence over employees (52%). According to this it's necessary rethinking by the manager of a basic behavior lines and interaction with employees which will lead to increase the quality of their work.

The next results introduce the connection between the force of reaching a work quality and other characteristics of the employees. The results are obtained after a correlation analysis.

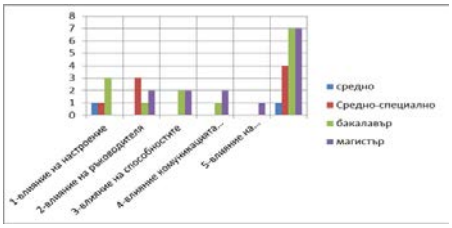
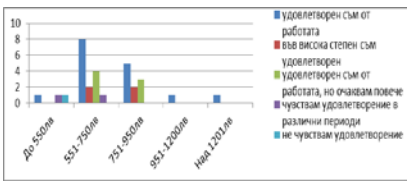


Fig. 4 *A connection between the education level and different influences that determine his quality of work*



I feel satisfaction in my work

I feel satisfaction but I expect more

I do not feel satisfaction at work

Fig. 5 *A connection between salary and work satisfaction*

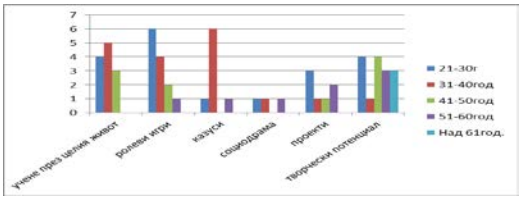


Fig. 6 *Evaluation of the implemented methods and technics according employee's age*

The analysis indicates that more than the half employees (51%) are at the age from 31 to 40 years old because the priority of the organization managers to hire young, active, purposeful people who can easily and trouble-free to communicate with clients in event planning. A characteristic of the young generation employees is the flexibility and the ability to adapt fast in changing conditions. The employees receive salaries around and above the middle salary for this line of business and the region it is located.

The role of the direct leader is essential for the quality implementation of obligations which is based on the high level of tension and dynamic in work. In the event organization and carry out is necessary enterprise and ingenuity to fulfill with unpredicted situations according to the specification of this activity and the lack of opportunity to "repeat" the event, in this train of thought the employee has no right to mistake.

The high educated employees indicate that the relationships and the contacts with clients have the strongest influence over their quality of work. Of prime significance for the company's activity is the quality relation with clients, meet client's wishes and ability of fast reaction of challenges in every new project.

The salary exercise straight influence on work satisfaction and according to the survey there are no employees who feel frustrated at work. This is connected with the work dynamic and variety that contribute to employee's positive attitude. In the company the salary is around and above the middle and are paid additional bonuses which is a motivation factor.

The inculcated methods and technics in the organization are well accepted by employees and they recognize their positive influence over work quality. The employees till the age of 40 prefer casus solving and taking part in role games. The use of the creative potential and the opportunity to take part in idea creation of events has a leading influence over employees by the middle-aged generation.

The survey connected with providing opportunities for raising the quality of human resources indicates the information gathered by employees in accordance to the implemented strategies, methods and technics for a better implementation of obligations.

Table 1*: Applied methods and technics*

№	Research of the applied methods and technics	NO	YES
1	**2**	**3**	**4**
1.	*A) investigation and identification of the employee's motivation attitudes*	25,7%	**71,7%**
2.	*B) encouragement of employees for independent taking a decision and initiative at work*	36,6%	**61,3%**
3.	*C) implementing a strategy life-long learning*	13,4%	**84,5%**
4.	*D) influence over employees using motivation mechanisms and technics*	38,3%	**61,7%**
5.	*E) using the method sociodrama*	61,5%	36,4%
6.	*F) employee's inclusion in projects*	63,6%	33,7%
7.	*G) taking part in role games and casus for problem solving*	23,3%	**73,9%**
8.	*H) creating opportunities for expression of a creative potential*	0%	**94%**

The results of this research confirm the implementation of good practices and methods for raising the quality of human resources. In the company are organized regular surveys for identifying employee's motivation attitudes, encouragement of the independent work and taking decisions. The strategy life - long learning is applied and the company uses the creativity of their employees. It's poorly practiced the method sociodrama and inclusion in projects.

4. Conclusion

The investigation of the opportunities for raising the work quality in full and its results confirm the making efforts and striving for the best labor performance both by managers and employees. In the fast developing global competitive society there is no place for companies that are not adaptive toward new conditions and environment. And in social attitude the adaption depends on the qualities of human resources.

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COMPETENCE-BASED MANAGEMENT IN PUBLIC ADMINISTRATION IN POLAND

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Abstract: *The aim of the article is to present the overview of the project "Processes, Goals, Competencies – Integrated Office Management" that introduced competence based management in public administration in Poland. The main goal of the project was to support offices of public administration in Poland in introducing new methods of management. The project had few stages which are described in the article. In the final part of the article the Author discusses future challenges of the project.*

Keywords: COMPETENCE BASED MANAGEMENT, HUMAN CAPITAL, PUBLIC ADMINISTRATION

1. Introduction

The concept of competence-based management was introduced in the 90. of the XXth Century by C.K. Prahalad and G.Hamel[1] [6] as a result of emerge of the new type organization – so called learning/intelligent organization. The modern competence based management can be defined as a way of personnel policy conducting where the main goal is to ensure the adequate competence resources for the company – the competencies that are necessary to fulfill strategic goals of an organization [3]. Competency approach is getting more popular as it is perceived as more flexible in comparison with traditional human resources management concept. The increasing popularity of competence based management is observed not only within enterprises' managers but also within managers of non-commercial organizations.

The aim of the article is to present the concept of competence-based management as an approach that can be used not only in enterprise but also in non-commercial organization. To achieve the goal of the study, the Author analysed a selection of literature on the subject. Moreover in order to illustrate the theoretical review with the case study approach the Author describes the project "Processes, Goals, Competencies – Integrated Office Management"[2] that was carried out in years 2014 and 2015 in the public administration in Poland.

2. Competency Model in HRM

The competency approach uses so called competency model which lists all competencies (together with definitions) that are crucial for the strategy and organizational goals [12]. To create good competence model one has to introduce multi-stage process that consists of:

1. Identification of key competences of an organization.
2. Identification of employees' competencies that are needed with respect to key competences of an organization.
3. Definition of employees' competencies together with so called behavioral description of job.
4. Creation of competency profiles.
5. Creation of coherent competency model.

The starting point in creation of the competency model is an identification of strategic fields of competitive advantage of an organization. These are so called organizational competences which describe the specific enterprise's opportunities, by identifying its strengths in the area of knowledge and experience. In turn organizational core competences determine the structure of competencies that are required from employees. On the other hand one has to remember that core competences of organization are the result of employees' knowledge, attitudes and skills. So it could be said that there is mutual relationships between organizational and employees' competencies.

There are different definitions of the term "competency" in the literature. For example employees' competence can be understood as: a characteristic of a person [1], the combination of knowledge[5], skills and qualities, mix of attitudes and personal attributes possessed by effective employee [2]. Due to the lack of one common definition of employee's competencies' components in the literature, there is a necessity to present the opinion of the Author of this article. For the purpose of the paper one can understand employee's competencies as: *Employees' disposal that refer to the knowledge, skills and attitudes that enable employee to fulfill professional duties on required level. The use and the development of competencies in the work process led to accomplishment of the organizational goals that are formulated in the strategy* [11]. It is worth to mention that competencies are the category that can be measured [9]. So that in the process of competence management one should remember about analysis of the levels of competence fulfillment by particular employee.

The next important step is to define all competencies that are used in the model. Definitions should be detailed enough to prevent ambiguity of interpretation. Definition consists of the name of competence and its short description together with examples of behavior that is typical for the competence (behavioral description of job) [10].

When using competence model one can describe appropriate job standards in organization by creation of so called competence profiles. They tend to show required level of knowledge, skills and attitudes on particular job position and are used to assess real competencies of employees. In turn this is the way to get high quality of human capital in enterprise as competence model helps to verify the level of employees' and/or managers' competencies. The result of assessment is then the basis for development plan of each employee/manager in organization. Hereby investment in human capital is more effective as it meets real needs of personnel.

The final stage of competency model creation is introducing it into all spheres of Human Resources Management in organization.

3. Competency management in public administration in Poland

Government administration influences the quality of citizens' life [4]. In Poland its main role is to guarantee professional and politically neutral execution of objectives of the State. This can be ensured only by competent and professional staff. In accordance one of the main goal presented in the document "Efficient state

[1] When one talks about organizational competencies one refers to the concept of „core competences" by C.K. Prahalad and G. Hamel. Core competences of the organization are its specific abilities (strengths) that enables the organization to provide the clients with added value.

[2] The project was introduced by Civil Service Department of the Chancellery of the Prime Minister and was supported by EU Social Funds.

strategy 2020"[3] [8] is enhancing quality of public administration provided by effective and functional institutions which are going to be managed modernly[4]. To fulfill the goal the project "Processes, Goals, Competencies – Integrated Office Management"[5] was carried out in Poland in years 2014 and 2015. The aim of the project was to support offices of public administration in Poland in introducing new methods of management. Action that was taken within the project referred to [7]:

1. Process management (identification, mapping, optimalization of key processes in the office and analysis of resources allocation),
2. Management by goals (working out the goal system that is coherent and integrated with management control in the office),
3. Competence based management (creation or updating of competence model in the office).

168 government administration offices took part in the project, 25 of them implemented competence based management and 11 other offices decided to improve their competence models. The project had few stages. At the beginning representatives of particular public institutions took part in seminars to get familiar with goals and schedule of the project. Then professional consultants conducted the audit of management methods and techniques in each of office that took part in the project. That was the basis for the implementation of new concept of management in particular offices. To do so consultants together with selected representatives of employees created project teams aimed at implementing modern management methods in office including competency management approach.

Competence based management was described as systematic action that leads to creation of competence standards which cause a rise of human capital and efficiency of an organization. The significance of competence based management in public administration offices was expressed by following goals:

1. A rise of effectiveness, promptness and conformity of the law task carried out by public administration thanks to well defined and possessed competencies,
2. A support of human resources management by using particular techniques/instruments of competence based management,
3. Describing and implementing of mutual connection and interaction between systems of competence based management and management by goals in accordance and with process of requirement, assessment and development of employees.

To raise the quality of human resources management in public administration consultants supposed to prepare or update competence model which supports managers in adapting employees' competencies to needs of particular office. For the purpose of the project different instruments of competence based management were worked out, for example: the formula of the competence audit, competence based interview, professional career path.

In the table 1. the Author presents action that was taken within different type of public administration offices in the module of competence based management.

Table 1. Action that was taken within different type of public administration offices

The type of the office	The type of action
Central Offices	Adaptation of standard competency model[6]to the specific needs of particular offices by identification key behaviors for different job positions and describing them in competency language.
Voivodship Offices	Creation of: competency models basing on standard competency model, the formula of competency audit, the rules for knowledge transfer, the formula of development talk.
Regional Offices of Measure	Implementation of competency model that aimed: more coherent expectation in reference of the same job positions, specify the expected behavior of employees, creation of evaluation scale for particular competencies, enabling the verification of competencies in the whole organization.
Regional Directorate for Environmental Protection	Creation of: competency model, competency audit, knowledge transfer. Implementation of mutual connection and interaction between systems of competence based management and process management, ecomanagement and audit.
Statistical Offices	Creation of: competency models basing on standard competency model, the formula of competency audit, the rules for knowledge transfer, the formula of development talk.
Inspection for Environmental Protection (provincial level)	Disseminating of competency model and audit of competence in the process of employees' assessment. Use of competency model in creation of individual plans for professional development.
Veterinary Inspection (provincial level)	Creation of competency model, strategy of requirement, policy of career paths, techniques of requirement interview, rules of giving feedback, rules of team management, competency audit and knowledge transfer.

Source: Own elaboration based on: [7].

4. Conclusion

The project Processes, Goals, Competencies – Integrated Office Management" is now finished. In Author's opinion application of competency approach in public administration was a good idea as it leads to new quality of management in offices. Nevertheless there are some fields of risks for the success of the project.

It is worth to stress that one of the main challenge was to prepare solutions of management problems in accordance with law regulations in offices. The rules of functioning of Civil Service in Poland are being defined in Act of 21 November 2008 on Civil Service. Additionally the most important guidelines of human capital management in public government administration are being identified in document "Ordinance no 3 of the Head of the Civil Service concerning the standards of human resources management in the civil service". For this reasons it must be remembered that not all of instruments of competency management could be applied in offices.

[3] The strategy is one of the nine integrated strategies that is introduced to rise the efficiency of public institutions by cooperation with citizens. The strategy was established by the government in 2013.

[4] Goal 5: Enhancing the potential of public administration as regards development of law and policies and providing high quality service and strengthening partnership mechanism.

[5] The project was introduced by Civil Service Department of the Chancellery of the Prime Minister and was supported by EU Social Funds.

[6] Standard competency model was created for the purpose of the project "Processes, Goals, Competencies – Integrated Office Management" as a starting point for introducing competence based management in offices.

Another challenge was to convince managers and employees to implement competence approach into human resources management and use it for the purpose of: an audit of employees' competencies during both requirement and periodic assessment of an employee, a description of job positions in an office, a development of employees. People usually do not like changes. When introducing competency management in offices employees and managers need to change the way they think about human capital management. This causes stress and fear of dismissal and in turn aversion to the project.

For this reason it is a question whether competency models are going to be used in practice what is important for a rise of effectiveness of human resources management. In this context there is a necessity for further monitoring of effects of project and to support offices' staff in making changes.

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NEW APPROACHES AND TRENDS AIMING AT ACHIEVING BETTER RESULTS IN EDUCATION

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Abstract: *Rapid globalization requires for students, teachers, and researchers to have good education, logical thinking, problem-solving, comparative, and research skills, excellent expressiveness, and broad scientific knowledge. This work outlines some of the newest and most important approaches and trends in the universities' education system aiming at achieving better results. Some of the latest main projects and examples of good practices related to the application of these approaches and to the international education in Japan, Bulgaria and the United States are also introduced in the paper.*

Keywords: EDUCATION, NEW APPROACHES, LOGICAL THINKING, COMPARATIVE SKILLS, RESEARCH SKILLS, PROBLEM-SOLVING SKILLS, ALTERNATIVE FORMS OF LEARNING AND EDUCATION, CONTEMPLATIVE WORKSHOPS

1. Introduction

Rapid globalization requires for students, teachers, researchers and experts to have good education, logical thinking, problem-solving ability, expressiveness, and broad scientific knowledge. To improve these skills and to help students advance in their abilities faculty needs to keep improving and developing the educational environment and to apply new educational approaches aiming at achieving better results. Globalization requires for a specialist who wants to go beyond the borders of their own culture to know at least English in addition to their own language.

In the Age of Globalization, international education has been rapidly improving in Japan, mainly instructed by the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT). The teaching of English as a foreign language plays an important role in various educational sites in Japan since not only English is recognized as the international official language but also Japanese as the native language in Japan is quite different from the English language with the respect to linguistics. There are not that many opportunities for people to use English in their daily lives in Japan, so the way they learn English in school becomes crucial for developing their English language skills. Recently many new attempts have been made across the nation, corresponding to the globalizing world [1-4].

In this paper, the latest main projects related to international education in Japan and some specific approaches in the Hiroshima Institute of Technology (HIT), based on projects promoted by MEXT, are presented. Some of the newest and most important approaches and trends in the universities' education system aiming at achieving better results and some examples of good practices related to the application of these approaches in the education in Japan, Bulgaria and the United States are also discussed.

2. International education in Japan and in Bulgaria

Education in Japan is generally classified as having two parts: elementary and secondary education and higher education. According to the International Education Division, Elementary and Secondary Education Bureau of MEXT, the policy is expressed as follows - it is necessary to educate people who can act independently with a global point of view in a society that is becoming more international. MEXT is working comprehensively on measures such as (1) enhancing education to deepen international understanding and teach foreign languages, (2) promoting international exchange, (3) enhancing education of Japanese children overseas, and (4) enhancing education for returning Japanese children from overseas and foreign children in Japan [1].

In addition, they proposed "English Education Reform Plan, corresponding to Globalization" in 2014. As the Olympic Games will be held in Tokyo in 2020, remarkable reforms have been conducted by the whole nation in Japan. At first, MEXT sets English Language Activities classes several times a week in elementary school, and classes will be conducted in English in principle in secondary school. Also, they suggested "Constructing Necessary Frameworks for New English Education" in order to empower teachers in both elementary school and secondary school. Finally, MEXT aims at such goal as to "Enrich English education throughout each stage in elementary, lower/upper secondary schools and improve students English ability (aim to pass Grade 2 or above in the Test in Practical English Proficiency, score over 57 in the TOEFL iBT test, etc.)" to improve the students' practical English language skills [2].

In Bulgaria, following their initial exposure to foreign languages in kindergarten, the students continue to study at least one foreign language such as English, German, French, Spanish, Russian, Italian, Japanese, etc. in elementary school. In high school the students continue their foreign language education and sometimes a second even a third foreign language is added to their curriculum. Knowing languages gives the students a lot more opportunities to communicate and exchange ideas and experience and to search and use information from global databases. In Universities, the students continue their studies in at least one foreign language as relevant to their field of specialization (engineering, mathematics, physics, biology, medicine, etc.). During the first 2-3 years students have mandatory classes in basic subjects concerning their education field. There are also programs in which all classes are taught in a foreign language (in English, German, etc.).

In Japan, there are such policies concerned with international education as "International Issue in Higher Education," "Support for Internationalization of Universities," "Designation of the "Locations in Japan of a Foreign University"," and "Promotion of International Student Exchanges" proposed by MEXT. For example, in 2012, "Project for Promotion of Global Human Resource Development" has been launched in order "to overcome the Japanese younger generation's" inward tendency "and to foster human resources who can positively meet the challenges and succeed in the global field, as the basis for improving Japan's global competitiveness and enhancing the ties between nations." [3]. Then, according to the Office for International Planning, Higher Education Policy Planning Division, Higher Education Bureau of MEXT, "Global 30 Project" has been requested to establish University network for

internationalization. Finally, "Re-Inventing Japan Project" has been suggested, which is "a funding project that aims to foster human resources capable of being globally active, and to assure the quality of mechanisms for the mutual recognition of credits and grade management through an international framework, by giving financial support to efforts for the formation of collaborative programs with universities in such countries as Asia and US, that conduct study abroad programs for Japanese students and undertakes the strategic acceptance of foreign students." [4].

At the same time, Japan has promoted to exchange students more than before as the project called "Promotion of International Student Exchanges" indicates. In 2010, Student Support and Exchange Division, Higher Education Bureau of MEXT has introduced "Study in Japan" establishing the exchange system to support foreign students who would like to study in Japan such as Japanese Government (Monbukagakusho: MEXT) Scholarship, Young Leaders' Program, and Japan Student Services Organization (JASSO).

The Erasmus Programme is the largest European initiative that has been enriching lives for the past 30 years. It started as a student mobility programme in 1987 and it has grown into something bigger and enriched the lives of more than 9 million direct participants, not to mention the indirect impact it has had on so many others. Since its creation, the Erasmus Programme has developed and expanded greatly and in 2014 many programmes were combined into one: Erasmus+. The programme is no longer focused solely on academic education. The 'plus' means that it now includes workplace traineeships, staff training and teaching activities, cooperation projects between universities, research organizations, companies, non-governmental organizations, local, regional, national authorities and other socio-economic actors – within Europe and beyond. Erasmus+ Programme will be offering mobility opportunities from and to all European Union Member States and beyond, for more than 4 million Europeans between 2014 and 2020 providing young Europeans with the opportunity to enhance their personal and professional development. The increase is due to mobility enhancement and to education globalization. Bulgarian Universities, Bulgarian Academy of Sciences (BAS) and other organizations in Bulgaria participate in this program actively. Erasmus+ is more than just mobility - with cooperation projects, it provides organizations active in the fields of education, training, youth and sport the chance to forge international partnerships which broaden opportunities for staff and students and drive reform.

3. New approaches in the universities' education system, examples of good practices and discussion

Institutions all over the world such as companies, scientific institutions, research centers, universities, etc. need personnel that can work abroad. It is of crucial importance to keep improving and developing the educational environment and to apply new educational approaches aiming at achieving better results and help students advance in their skills and abilities.

Some of the newest and most important approaches in the universities' education system aiming at achieving better results are:

- incorporating alternative forms of learning and education into the traditional classroom model such as study abroad programs, internships, field trips;
- working across fields and disciplines to provide information to the students and track their progress on comparative skills, research skills;
- incorporating contemplative workshops giving the students the skills and tools to deal with time management, stress, happiness, change, and many other aspects of emotional, psychological and physical well-being and health which are crucial for the successful outcomes of the education process.

This is one of the latest and most popular trends in education in the United States. Researches just recently discovered the concept of neuroplasticity and most colleges and universities are developing and implementing classes and workshops on it. For many years we all believed that with age our brain deteriorates and our brain cells decrease in both size and number, which means we get much worse at processes such as learning, memorizing, problem-solving, paying attention, focusing, etc. This theory, however, was just recently proven wrong. Neuroplasticity means that our brain cells are very 'plastic' and flexible. Their size and number has no correlation with age; it is very much relate and responds to stimuli such as one's lifestyle, emotional state, physical state, etc. Our brain cells can be trained just like we train our muscles at the gym. For example, we can teach our brain how to, instead of constantly scanning the environment for the negative which is its natural state, scan the environment for the positive through journaling, gratefulness, random acts of kindness, forgiveness, mindful meditation, healthy diet, and exercise. Our brains scanning for the positive every day will have a tremendous impact on our serotonin and dopamine levels, which would lead to a much better emotional and physical health, increased productivity, longer attention span, a better ability to focus and solve challenging problems, decreased level of chronic anxiety and stress and absence of the health complications associated with them.

- one on one coaching and mentoring by experts in the students' fields of interest.

A good example of this important approach aiming to improve the education system and to achieve better results is the National Program "Internships for students" in Bulgaria. This program funded by the Bulgarian Ministry of Education and Science started again in September 2016 after the excellent results that the 2013-2014 program showed. This Program is for individual training for students in academic organizations such as research institutes in the Bulgarian Academy of Sciences (BAS), in companies, etc. The program offers each student 240 hours of individual training under the coaching and mentoring of experts (mentors) in the students' fields of interest. The mentor works with each of them to design an individual schedule for the internship, keeping in mind the students' schedules. The mentors help students gain new knowledge and specific professional skills. The Institute of Electronics, BAS (IE-BAS) participate actively in this program. For example, mentors from the Laboratory "Physical problems of electron beam technologies", IE-BAS work under this Program with students from different universities such as Technical University – Sofia, University of Mining and Geology is "St. Ivan Rilski", University of Chemical Technology and Metallurgy in Sofia, etc. in the field of electron beam technologies - processes at e-beam treatment of materials, modeling, optimization and process control.

HIT has kept developing and promoting the new systematic approaches as higher education in order to improve students' skills and abilities, based on social needs and the school's foundation idea and spiritual legacy that "education is love." In 2016, the newest educational project called "HIT 2016" that aims at better education for students has been launched. The project includes introducing portfolio-system to care students, active learning in classes, and follow-up program to have students acquire their basic knowledge of mathematics, physics, and English. Now, main projects have been carried out, which aim to improve students' communication ability, logical thinking, problem-solving ability, and expressiveness, corresponding to globalization such as The Center of Project for Educational Development, The Center of Project for Research, HIT 2016, etc.

The Department of Electronics and Computer Engineering in HIT is trying to develop new systematic approaches both in research and education for students, adding to the existing programs. Research approaches and incorporating other students in such activities are taught in each seminar in their senior grade. Students can learn and improve not only their academic skills but also their logical thinking, problem-solving, communication ability, and expressiveness, through their research projects in seminars. There are three main fields (Electronic Devices, Electric and Electronic Circuits and Computer and Electronic Information) and

nine laboratories for graduation research in the Department. Usually, students select areas of interest after completing two years of courses covering engineering fundamentals and liberal arts. They pick up their topics they would like to research among these subjects, and belong to one laboratory among nine. In addition to this seminar system, mainly these three new projects are working now: Techno-club and Tech-ners Jr., Active learning in the class "Basic Electric Circuits" and Hosting international or domestic workshops in HIT.

Usually, Japanese university students in science and technologies do research and attend scientific conferences and workshops in fourth grade and graduate schools. By doing research, students are able to acquire problem-solving, logical thinking, presentation and discussion skills. Research activities and presentations are very important for active learning. Active learning is one of teaching methods that strives to involve students more directly in the learning process. Students can acquire many abilities by active learning that cannot be learned in traditional classroom lectures. On the other hand, almost first and second grade students take traditional classroom lectures and tend to be passive learning attitude. Many students tend to study only to memorize knowledge, and they cannot expect great growth. Therefore, we have adopted active learning elements in lower grade class so the students are able to learn actively earlier.

The class "Basic Electric Circuits" for first grade students with active learning has been carried out [5]. The adopted active learning methods are flipped learning, group learning, and peer support. Before the class, students should study what was taught during the previous class, and prepare for the next class with textbooks, lecture videos, handouts. These educational materials are delivered via internet, and students can learn anytime and anywhere by using smartphones and tablets. At first, students take an assessment test. We encourage the students to study on their own and prepare for class by having the test. Subsequently, a teacher gives a short lecture about main points only. Students study the next contents beforehand for the class so that lecture time can be shortened. After the lecture, the students practice individually and at that time, senior students support the first graders. The number of supporters is about 7 for 70 first graders. Thus, the students can teach exercise problems each other in groups. The groups are a mix of students with various levels of knowledge and skills. Students with poor knowledge in electric circuits can overcome their weak points with classmate supports. At the same time, the good students get a better understanding by teaching others. Teaching is one of the best learning methods. Furthermore, the students can improve communication and presentation skills. Finally, the students take a confirmation test. Not only the results of the individual tests, but the average points of each group are also evaluated. By evaluating the average points of the groups, we encourage students to teach each other.

The following questionnaire was used for students' evaluation of the class utilizing active learning method and the results are shown in Figures 1-5. *Question 1* (to students): Do you think that teaching or being taught is useful for your study? *Question 2* (to students): Compared to the traditional lectures, was this class useful for you? *Question 3* (to students): Will you consider becoming a supporter next year? *Question 4* (to support students): Was your participation in this program useful for improvement of your skills and abilities? *Question 5* (to support students): Was supporting junior students rewarding for you?

Fig.1 shows that 82.4% of students think that teaching to classmates or being taught by classmates is useful for learning. There are students of quick understanding and poor students in the same class. It is difficult to obtain high satisfaction among all the students using one lecture method. However, by adopting teaching each other, we can obtain high satisfaction level among many students. In addition, students who play roles as teachers can get a better understanding by thinking about how to teach. Fig.2 shows that 70.6% of students think that the class utilizing active learning is more useful than traditional classes. Some students said that it was easier to ask classmates than to ask a teacher. We were able to get a good evaluation for the class. However, this method requires seniors who support juniors. As shown in Fig.3, 20.6% of students said they would cooperate with the class, and this method can be continued with new supporters. We also surveyed support students. The results in Figs. 4 and 5 indicate that the supportive students were satisfied and that supporting others improved themselves. The results confirm that classes can be improved better by introducing active learning elements in traditional classes and we will continue to work for improvement our classes.

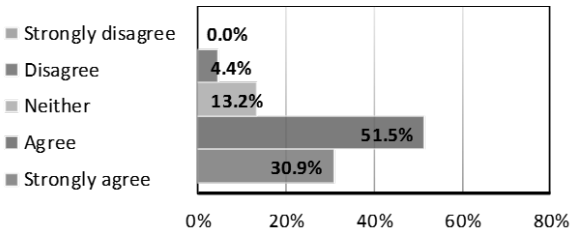

Fig. 1 *Results for answers of question 1.*

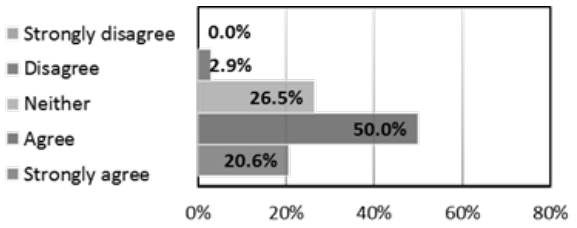

Fig. 2 *Results for answers of question 2.*

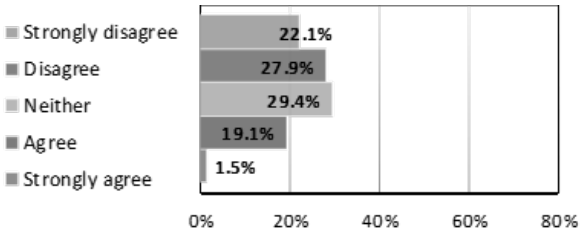

Fig. 3 *Results for answers of question 3.*

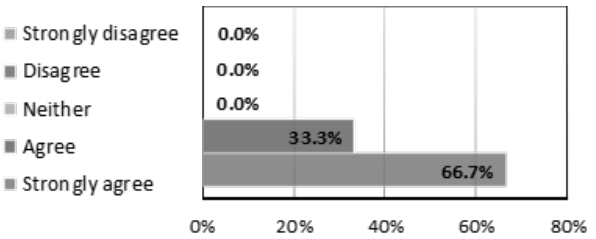

Fig. 4 *Results for answers of question 4.*

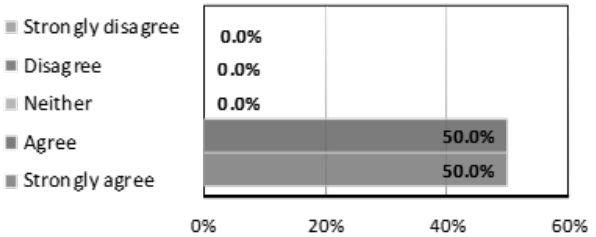

Fig. 5 *Results for answers of question 5.*

Recently, graduates, who have abilities of making presentations, debating, good communicating, etc., are desired in many companies in Japan. Universities have to turn out successful graduates for society. To acquire experiences of making presentations in scientific forums (conferences, workshops, etc.) is one of the effective learning methods for helping students advance in their practical communication abilities and for improving their

expressiveness, logical thinking and problem-solving abilities. In engineering faculties of many national universities in Japan, students belong to a laboratory while at fourth grade and many of them take master's courses while at graduate school and start to work after completing their master's degree. So, these students have a chance to attend scientific forums during three years. In HIT, many students after graduating from the undergraduate course start to work in the society (Fig.6). These students do not have experience in attending conferences, because they have only a year and a half before graduating. It is expected that all students have experience in attending scientific forums, which sometimes can be challenging.

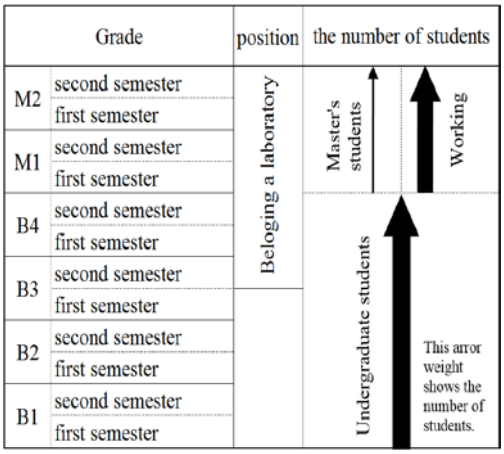

Fig. 6 *Flow of students in the Dept. of Electronics and Computer Eng., HIT.*

Faculties in the Department of Electronics and Computer Engineering and in the Department of Electrical Systems Engineering in HIT organize a domestic scientific forum - Education and Research Workshop of Electronic Devices, Circuits, Illuminations, and Systems (ECIS), which is held twice a year. The sponsor of ECIS is "The Illuminating Engineering Institute of Japan: The Regional Branch of Chugoku District." Since the homepage of ECIS is opened people can apply their research presentations and attend the workshop. Because ECIS is convened in our university HIT, many students in HIT are able to attend the workshop easily and to make presentations.

The 4th ECIS took place on November 26th, 2016, a questionnaire for participants was prepared and the results were considered. There were one keynote speech, one special speech, four oral presentations, and fifteen poster presentations. The number of participants is shown in Table 1. The students are almost 73% that shows high students' activity and around 40% of them made presentations. The questionnaire included the following questions: *Question 1*: Is this your first participation in a workshop? *Question 2*: Do you have a presentation / presentations in this workshop? *Question 3*: If you have a presentation in this Workshop, is it an oral or a poster presentation? *Question 4*: If you have a presentation in this Workshop, in which language it is – in English or Japanese? *Question 5*: If you have a presentation in this Workshop, how many authors are there in your paper? *Question 6*: In which level of your education you are now? *Question 7*: In which areas you heard and learned new knowledge at this Workshop? *Question 8*: Did you participate in the Workshop in HIT in November 2015?

The results of the questionnaire are shown in Table 2. Almost 62% of the students participated for the first time, and almost 54% of students heard and learned new knowledge at this workshop The results show that some students are interested in scientific forums and students learn not only from the presentations made by themselves, but also they learn new knowledge from presentations made by others. Many students, who do not belong to any laboratory yet, participate in this workshop. Based on the results, we can conclude that it is important for students both to make a presentation and to get good experiences. One of the graduates from our department says, "I learned technical way of making presentations, and this experience is very useful for improving practical skills in my work."

Table 1: *Number of participants in the 4th ECIS.*

Number of participants	Number of students	
	Made a presentation	Just audience
66	19	29

Table 2: *Results of the questionnaire.*

Number of answered persons	Number of answered students	Number of students who heard and learned new knowledge	Number of persons of first-time attendance	Number of students of first-time attendance
50	37	20	26	23
Number of student in each grade				
B2	B3	B4	M1	
2	14	18	3	

Bulgarian Universities and research institutes of BAS have well established traditions in organizing and hosting scientific forums such as conferences, workshops, training sessions, etc., in which students can participate and deliver presentations [6]. Some of these forums are organized specifically for students in order to improve and develop their skills and abilities - expressiveness, logical thinking, problem-solving and decision-making abilities, etc. For example, the following scientific events are organized by the IE-BAS: (i) the International Conference on Electron Beam Technologies (EBT) starting in 1985. Students from HIT lead by Prof. T. Tanaka participated in the last EBT conferences (in 2014 and in 2016) and presented their results. (ii) The International Summer School on Vacuum, Electron and Ion Technologies and the 2017 edition is the 20th in a series of events; (iii) the International Conference and School on Quantum Electronics, organized biennially since 1980.

4. Conclusion

Some of the newest and most important approaches and trends in the universities' education system aiming at achieving better results such as: (i) working across fields and disciplines to provide information to the students and track their progress on comparative and research skills, (ii) incorporating alternative forms of learning and education into the traditional classroom model such as field trips, study abroad programs, internships, exchange programs for students, teachers and researchers, (iii) one on one coaching and mentoring by experts in the students' fields of interest, (iv) incorporating contemplative workshops giving the students the skills and tools to deal with stress, time management, happiness, change, and many other aspects of their emotional, psychological and physical well-being and health which are crucial for the successful outcomes of the education process, are presented in the paper. Some of the latest main projects and examples of good practices related to the application of these recent approaches and to the international education in Japan, Bulgaria and the United States are also introduced and discussed.

Institutions all over the world such as R&D centers, companies, scientific institutions, universities, ministries, etc. need personnel and experts that can work abroad. It is of crucial importance to keep improving and developing the education environment and to experiment with new education approaches to help students advance in their skills and abilities, so that the quality of their education can ensure the success of their future careers either in their home countries or abroad.

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PROBLEM AREAS OF KNOWLEDGE IN A KNOWLEDGE ORGANISATION

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Abstract: *A knowledge organisation should constantly expand and grow in order to survive in today's competitive environment. One of the key opportunities to do so is allowing employees to use the accumulated knowledge. Organisations should enable employees to share their knowledge, while employees should be able to communicate and collaborate voluntarily and immediately, create new knowledge and accumulate individual knowledge. Although the need for knowledge is clear, knowledge movement at all stages of the knowledge life cycle is characterised by leakage, depreciation, dependence and trust. The article aims to review scientific literature and analyse knowledge issues in a knowledge organisation. To achieve this aim the following objectives have been set: analysing the concept of knowledge as a key resource in an organisation, examining the concept of organisation using a systematic approach and giving a critical overview of the scientific literature on this issue, justifying the need for knowledge at different levels and identifying problematic aspects of knowledge in a knowledge management process. The research applies methods of logical analysis, abstraction and synthesis.*

Keywords: KNOWLEDGE, KNOWLEDGE ORGANISATION, KNOWLEDGE MANAGEMENT CYCLE

1. Introduction

Knowledge has been analysed and investigated by many scholars: Drucker and Peter (1969), Bell (1973), Toffler (1980), Ackoff (1989), Argyris (1993), Albrect *et al*. (1993), Nonaka and Takeuchi (1995), Eulgem (1998), Davenport, Prusak (1998), Ulrich (1998), Malhotra (1998), Stewart, Leopold (2002), Bornemann, Sammer (2003), Gudauskas, Ramanauskienė (2004), Atkočiūnienė (2005), Lukoševičius (2005), Probst, Raub, Romhardt (2006), Ley (2006), Čivilis (2006), Stonkienė (2007), Činčikaitė, Janeliūnienė (2010), Girdauskienė (2012). It has been viewed as a research object since the times of Socrates (469–399 BC), Plato (427–347 BC) and Aristotle (384–322 BC).

Based on the issues of knowledge research and knowledge management research, three generations are distinguished. Researchers from the first generation of knowledge management rely on a structural approach, whereby different expressions of knowledge management characteristics lead to different maturity levels of knowledge management systems. Researchers from the second generation have created a basis for tacit knowledge management. Knowledge management research has allowed looking at knowledge management through a procedural point of view, analysing knowledge activities and transformation, moving along the knowledge life cycle from acquisition to storage (Girdaukienė 2012). Researchers from the third generation have combined the previous approaches, suggesting complex knowledge management and evaluation (Table 1).

Table 1. *Generations of knowledge research (made by the author based on Girdauskienė 2012)*

Research generation	Authors, year	Approach	Research aspect
1st generation	Churchman, 1971; Applegate, 1988; Drucker, 1989; Anthies, 1991; Gopal and Gagnon, 1995; Maglitta, 1996; Bair, 1997; Albert, 1998; Malhotra, 1999; Goodman and Darr, 1999; Hansen *et al.*, 1999; Boisot, 1987; Pautzke, 1989; Hedlund and Nonaka, 1993; Blacker *et al.*, 1993; Oberschulte, 1994; Nonaka and Takeuchi, 1995; Greshner, 1996; Spender, 1996; Polyani, 1996; Wilke, 1996; Güldenberg, 1997; Probst, Raub, Romhardt, 1997; Laim, 2000; Hahn and Subramani, 2000	Structural	Examines characteristics of knowledge. Presents understanding of the transfer, encoding and storage of organisational systemic knowledge through information systems. Created knowledge management systems. Built a foundation for a formalised concept of knowledge management.
2nd generation	Nonaka, 1994; Galagan, 1997; Earl and Scott, 1999; Nissen, 1993; Wiig, 1993; Probst, 1995; Schulanski, 1996; Choo, 1996; Andersen and APQC, 1996; Marquardt, 1996; Holsapple and Joshi, 1997; APQC, 1997; PWaterhouseCoopers, 1997; Ruggles, 1997; Van Der Spek and Spijkervet, 1997; Alavi, 1997; Van Heijst, Van Der Spek and Kruizinga, 1997; Van Der Spek and de Hoog, 1997; Davenport and Prusak, 1998; Wiig, 1998; Coombs and Hull, 1998; Tessun, 1998; Saint-Onge, 1998; Despres and Chauvel, 1999; Skyrme, 1999; Gartner group, 1999; Nissen combined model 2000; Accenture, 2000; Ernst and Young, 1999; Young, 1999; Liebowitz, 2000; Grant, 2000	Procedural	Analysed the transformation of knowledge when moving through the knowledge life cycle. Examined organisational learning as a tool to ensure knowledge management or organisational knowledge. Explains how learning transforms individual knowledge into organisational knowledge, corrects mistakes and improves work processes.
3rd generation	Swart, Harvey, 2012; Pinho, Rego, Cunha, 2012; Cyert and March, 1963; Argyris and Schon, 1978; Fyol and Lyles, 1985; Boisot, 1987; Levitt and March, 1988; Senge, 1990; Huber, 1991; Lave and Wenger, 1991; Brown and Duguid, 1991; Augustinaitis, 1992, Hedlund, 1993, Nonaka, 1994; Boland and Tenkasi, 1995; Snell and Chack, 1998, Crossan *et al.*, 1999; Harvey and Denton, 1999; Brennan, 2001; Hall, 2001; Nichani, 2001; Greenberg, 2002; Butler, 2002; Jucevičienė, 2004	Systematic	The focus is on knowledge creation, innovation and organisational learning in all business processes, from the strategy to the operational level. Integrated information technology into a solid organisational framework.

When dealing with today's problems and socio-cultural situations, the emphasis is put on the concept of a harmonious man. Management theories actualise a systematic approach focused on professionalism, i.e. professional performance and universal quality management (Katinienė, Skačkauskienė 2014). The most important role in the development of humanity so far played the ability to learn and use acquired knowledge (Kloudová, Chwaszcz 2011). Some of the knowledge used at work increases the organisation's competitiveness. The more competitive organisations exist, the more competitive the economic sector and the country itself become (Jurevičienė, Komarova 2010). Systematically and purposefully used knowledge gives an advantage to organisations, while employees' knowledge, ideas and skills are the driving force behind a successful organisation (Skačkauskienė, Katinienė 2015).

With the current social and economic developments and technological progress as well as the emerging knowledge society and knowledge economy, knowledge is becoming a crucial factor, ensuring the successful use of human resources integrated into all areas of a modern life and the effectiveness of all specialists (Melnikas, Smaliukienė 2007). The latter circumstance creates the need to look for new ways to ensure knowledge sharing and the ability to improve knowledge management in organisations in a

targeted and timely manner. The article therefore aims to review scientific literature and analyse knowledge issues in a knowledge organisation. To achieve this aim the following objectives have been set: analysing the concept of knowledge as a key resource in an organisation, examining the concept of organisation using a systematic approach and giving a critical overview of the scientific literature on this issue, justifying the need for knowledge at different levels and identifying problematic aspects of knowledge in a knowledge management process. The research applies methods of logical analysis, abstraction and synthesis.

2. Knowledge as a key resource

In the face of changing technologies and rapid market globalisation processes, business development, competitiveness, innovation and building as well as maintaining relations have become extremely relevant issues both theoretically and practically. Organisations are forced to respond and develop change their management skills to ensure their competitiveness and business development opportunities (Katinienė, Skačkauskienė 2014). Many researchers of modern organisation's operation claim that today and, in particular, in future knowledge about prospect technologies, changes in consumer needs, nature, environment, people's way of thinking and cultural processes will be the main resource for organisations' improvement and development (Morkvėnas 2010). Dave, Dave and Shishodia (2012) state that knowledge management brings together different types of knowledge and creates a system from two different sources: people and technology.

Management structures and organisational measures are increasingly determined by configurations of information flows, knowledge content, skills of different people to create new knowledge and thereby influence societal processes. Normally, transformations in a society take place in the following stages: agrarian (agricultural), industrial and knowledge (information) society (Table 2).

Table 2. *Stages of transformation (made by the author)*

Type of society	Description of economic activities	Limiting factor
Agrarian (agricultural)	Food production-related economic activities	Farmland area
Industrial	Economic activities focused on the production of goods	Available capital
Knowledge (information)	The basis of economic activities is knowledge creation and use in all activities	Quantity and content of the available knowledge

Agrarian (agricultural) society is a stage of economic development, where most income comes from agriculture and investments are made into the use of natural resources and land cultivation (crop production and animal husbandry).

Industrial society is a stage of economic development, where most income comes from industrial sectors and investments are made into the recycling of natural resources and production.

Knowledge (information) society is a society which is constantly collecting information in all sciences and industries. By processing this information at a later stage it is learning and creating new knowledge as well as adapting this knowledge in its life and work (Karazijienė, Sabonienė 2010).

Scholars suggest a fourth stage – a knowledge network society, where people with certain knowledge form a basis for economic activities. Organisations must respond to the dynamically changing environment. Innovative, new knowledge is becoming increasingly important, leading to the emergence of such concepts as knowledge organisation, knowledge economy and knowledge society. The importance of new knowledge is significantly growing. Creating it requires creative thinking, new management and administrative skills and innovative operational models. It is therefore hinted that such society should be called a creative society.

Being free to communicate, employees share necessary information and knowledge, which they can later improve and use more often (Girnienė 2014). Means of communication are becoming more relevant since innovation requires skills to discover, understand, use, change and share knowledge and experiences. Information technologies enable fast communication and knowledge exchange by different video, audio and written means and techniques, thereby creating communication and cooperation relations. This type of society is therefore suggested being called a relations society. However, many researchers, public figures and heads of organisations unanimously agree that knowledge is a basis of economic activities in a modern society.

Transformation into a knowledge society changes consumer needs, structural units of organisations and priorities of resources. Resources are divided into two groups: material resources are resources that can be seen and measured (equipment, buildings and even official organisational structure), while intangible resources are assets forming organisational culture (knowledge, mutual trust between managers and subordinates, innovation and managerial skills (see Fig. 1).

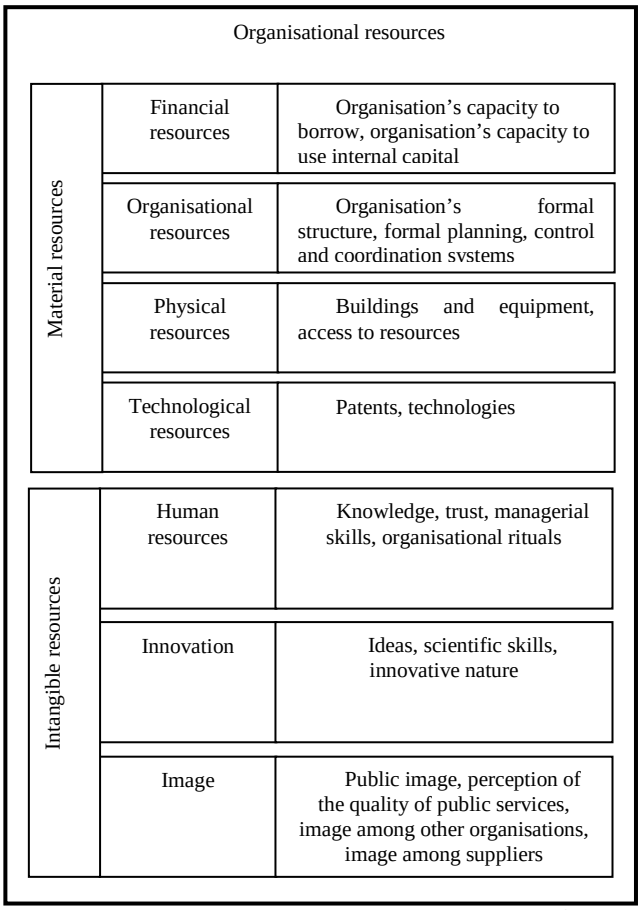

Fig. 1. *Organisational resources (designed by author with reference to Melnikas and Smaliukienė 2007)*

Not only information and information management become an important asset, but knowledge and its effective management as well (Raudeliūnienė, Račinskaja 2014). Knowledge, in particular tacit knowledge, gives a competitive advantage to an employee in the organisation (Reychav, Weisberg 2009). Knowledge is a unique resource. It is expendable the same as material resources. Organisations have entered a stage where the value of intellectual capital is several times higher than the value of material tangible assets.

3. The concept of knowledge organisation: critical point of view

Every person has much content and various needs of different importance – constant and episodic, explicit and very vague. After the man understood that joint efforts allow them to meet certain needs more easily or better, it gave an important incentive to increase one's changes of forming certain structures where people

are one way or another related by common activities (Katinienė, Skačkauskienė 2014). To this day it is popular to call these structures organisations (Bivainis 2011). Organisations are systems, the management of which requires the following general conditions:

- a system must have a goal. It is set by the system itself, its environment, i.e. other systems, or by the system together with other systems;
- the controlling component of the system must be able to influence the controlled object (direct link) and accept information about the state of the controlled object's environment (feedback);
- the controlled object must be able to accept impacts of the controlling component and change its state accordingly.

According to the systematic approach, an organisation is considered an open system: different objects and forms of activity are connected into a whole based not only on the existence, but also on links, interrelations and operational schemes of objects in an organisation as well as patterns in changes of objects, thus helping to identify development patterns and find new sources of synergy (Skaržauskienė 2008). The aim of an organisation is to meet consumer needs and receive benefits (Bagdoniene, Zilione 2009). The success of an organisation depends on the environment, both external (macro-environment) and internal (micro-environment). An organisation can exist and develop, if the external environment is sufficiently favourable to its operation and the internal environment is being properly created and fostered, in conformity with requirements of rationality and optimality (Ginevičius, Sūdžius 2005). There are different kinds of organisations. Every one of them is unique and in different situation, even though they may carry out the same activities (Bivainis 2011). Among the names that are most commonly used by scholars and researchers today are learning organisations, network organisations, creative organisations and knowledge organisations. They all have been attributed key characteristics (Table 3).

Table 3. *Types and key characteristics of different organisations (made by the author)*

Authors	Type of organisation	Key characteristics	Expression of types of knowledge
Senge 1990, Augustinaitis 2001, Peleckienė 2015	Learning organisation	Personal mastery, systematic thinking, group learning, common vision, sharing new knowledge, analysing gained experience and anticipating operational perspectives	Explicit knowledge
Pelz and Andrews 1966, Stankiewicz 1980, Martin and Skea 1992, Hollingsworth and Hollingsworth 2000, Unsworth and Parker 2002, Fuchs 2009, Girdauskienė, Savanevičienė 2010	Creative organisation	Balance between production and creativity, trust, motivation, knowledge, skills talent, creating new knowledge	Tacit knowledge
Romme 1996, Castells 2005, La Rua 2008, Gotea 2010, Raeymaekers 2010	Network organisation	Communicating knowledge by networks, constant sharing of contacts and new knowledge	Explicit knowledge
Nonaka and Takeuchi 1995	Knowledge organisation	Creating new knowledge, sharing experiences, dynamic activities, external environment requiring radical changes Combining knowledge/information databases and people's skills to ensure benefits and effectiveness	Explicit knowledge Tacit knowledge

Lyly (2012) claims that the concept of *learning organisation* took a meaning in 1980, when business companies used learning to increase their growth, competitiveness and resistance to external factors. Senge (1990) described the concept of learning organisation as a process combining several essential elements, the so-called disciplines: personal mastery, changing opinion, common vision, team (group) learning, systematic thinking, analysing gained experience and anticipating operational perspectives. Organisational learning means creating and developing knowledge that is important to the organisation's goals and available to all members of the organisation. Knowledge is a basis of innovation (Girnienė 2014).

Creative organisations are those environments, contexts and surroundings, the characteristics of which are such that they exert a positive influence on human beings engaged in creative work aiming to produce new knowledge or innovations, whether they work individually or in teams, within a single organisation or in collaboration with others (Hemlin *et al.* 2004). The organisation's flexibility, organic quality and ability to adapt to constantly changing environment are supported by an open culture (Hemlin *et al.* 2004), encouraging to trust and act in teams, and by leaders who inspire to create, experiment and risk, enabling their employees – who can be relatively divided into administrators and creators – to act and make creative decisions (Girdauskienė, Savanevičienė 2010).

Globalisation processes and needs of knowledge society pose new challenges and requirements to be met in all areas of the socioeconomic development and scientific and technological progress of a modern society (Melnikas *et al.* 2014). Different networks, acting from family to society, facilitating the finding of solutions for knowledge management-related problems and assisting in knowledge dissemination are considered to be a promising and effective organisational form. According to Castells (2005), in a modern age of globalisation and information technology development, many functions and processes are implemented through networks. Moving from information society to knowledge society changes social needs of an individual, thereby creating conditions for networking. Lately, scholars from different fields (De La Rua 2008, Gotea 2010, Raeymaekers 2010) urge both practitioners and theorists to join into networks. Networks and communities should be created in organisations, where employees could examine issues they are interested in, learn and improve (Girnienė 2014). Forms of *network organisations* can promote learning and new synthesis of information which is qualitatively different from the one disposed by different actors. And it is not just a mere improvement of the transfer of information between two different actors, but more like regular constacts that can provide new knowledge (Podolny, Page 1998). In other words, a network becomes a place for innovation. After all, the most useful information is rarely the one transferred in an organisation in a formal chain of command or the one that may be anticipated from price signals (Ribišauskienė, Šalengaitė 2013).

The most important asset in a knowledge society is knowledge. When available and in use, it gives a competitive advantage to an organisation. Through communication and mutual cooperation employees create new knowledge and use it to innovate. The dynamism of activities, external environment requiring radical changes, employees' learning and knowledge play an important role in the success of an organisation. To ensure benefits and effectiveness, knowledge/information databases and people's skills are combined.

Summing up, it can be argued that a *knowledge organisation* has characteristics of learning, creative and network organisations. In general, to ensure successful development and competitiveness, modern organisations must constantly change, learn and create new knowledge in a challenging business environment (Girdauskienė 2012).

4. The need for knowledge

Different scholars, for instance Marshall, separate management from other factors of production (land, work and capital). Schumpeter also agrees with the statement that management is an individual economic activity related to the introduction and administration of innovation (Appleby 2009).

Management means a process where limited resources are combined to achieve goals. Brech gives a different definition of management: it is a social process, encompassing responsibility for effective and economic planning of a company's operation and leadership in implementation of the objective or task set (Appleby 2009). A process is a totality of interlinked or interacting actions of an organisation, which transform inputs into results (outputs). In the practice of organisations, a process is understood as a chain of actions (intermediate steps to achieve the result) with a defined beginning and ending (Ruževičius 2007). A process connects material, financial and human resources for the desired result. It is unique for every organisation. There are no identical organisations and therefore there is no uniform group of business processes. However, the following groups are the most common: management, key processes and supporting processes (Klimas, Ruževičius 2009) (see Fig. 2).

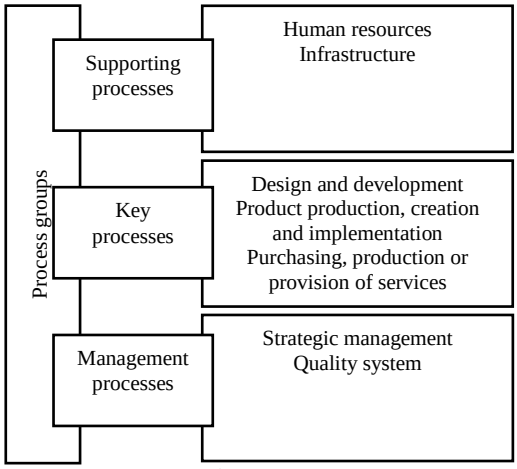

Fig. 2. *Groups and content of processes (designed by the author based on Klimas and Ruževičius 2009)*

Everything starts with a man – unique and distinctive personal knowledge forms a unique personal culture, allowing the man to express creativity and create new knowledge. Personal knowledge is the main driving force of operation, facilitating development, the achievement of new objectives, and communication and cooperation with other people. Using available knowledge at work a person can become more competitive, get a higher salary, create added value and acquire new knowledge. Dealing with simple, personal or complex, multifaceted and global tasks requires sharing knowledge between members of scientific, business or public sector organisations.

The biggest changes in an organisation are caused by knowledge dissemination and technological progress. Senge (1990) emphasised that only open and learning organisations would be able to generate a higher added value, acquire a competitive advantage, deal with difficulties and improve their management processes, systematically and purposefully manage and create environment which was favourable to effective knowledge management processes and organisational objectives. The modern society needs organisations that are ready for complex knowledge dissemination and management processes.

Drucker (1980) and Strassmann (1998) were among the first ones to talk about the importance of information and knowledge expressed in words – it is one of the most important and special resources, which, when in use, can bring significant benefits to the country's well-being (see Fig. 3). The need for knowledge arises primarily because of the public need and desire to create knowledge to ensure economic and social welfare and satisfy curiosity in this welfare, also because of the competitive advantage, ensuring necessary conditions for a stable economy, characterised by the implementation of effective national policies, a stable financial system and the maintenance of an effective market (Kriščiūnas, Daugėlienė 2006).

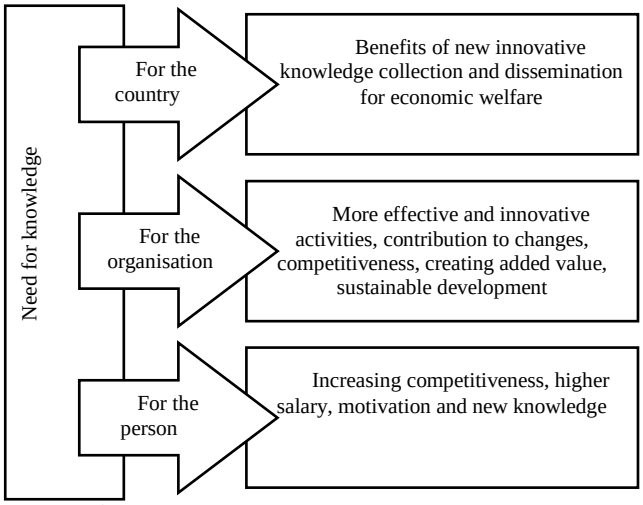

Fig. 3. *Need for knowledge (designed by the author)*

Summing up, it may be argued that the need for knowledge is very important at a personal, organisational and national level, and that effective knowledge management brings benefits to all market players. People are the key asset of an organisation, helping achieve its goals. It is one of the conditions necessary for the development of regular innovative activities.

With the constantly growing quantity of knowledge and possible loss of tacit knowledge, it is increasingly difficult to manage knowledge. To adapt knowledge in an organisation effectively, targeted technological solutions – knowledge management systems, i.e. information systems that structure knowledge management, are used (Girnienė 2014). Knowledge assessment is being increasingly improved. New knowledge management models enable further acquisition, dissemination and application of knowledge. Models are brought closer to the man – they facilitate not only knowledge management, but also the creation of motivation systems, revision of organisational strategies and focusing on career aspirations.

5. Models and problem areas of knowledge management

Speeding up effective work and operational processes, exchanging information and maintaining complex relations between members of an organisation require knowledge management. To manage knowledge, it is important to focus on knowledge sharing, examine synergy processes and analyse the speed of knowledge transfer through networks. The research on this subject is very limited or very episodic, covering only one area.

A successful organisation must store and develop knowledge as well as facilitate knowledge sharing among employees. Knowledge is cyclical in nature and must be updated. Knowledge management life cycles have been analysed by a number of scientists, including Wiig (1993), Bukowitz and Williams (1999), Dalkir (2005), Voehl and Harrington (2006), Conley and Zheng (2009). Andreeva, Kianto (2011). Nonaka *et al.* (2000) introduced a knowledge management model, where knowledge is divided into explicit and tacit (see Fig. 4).

Level of use / Type of knowledge	Group	Personal
Explicit knowledge	Systematic Systematised and grouped knowledge (documents, databases)	Conceptual Knowledge established in daily activities (concepts of product, value of a trade name)
Tacit knowledge	Routine Conventional and established knowledge in organisation's daily activities (organisational culture)	Experiential Tacit knowledge shared through joint activities (emotions, feelings)

Fig. 4. *Knowledge management based on knowledge classification (made by the author based on Nonaka et al. 2000)*

Beers, Boshuizen, Kirschner, Gijselaers (2005, 2007), Shum, Cannavacciuolo, Liddo, Iandoli, Quinto (2013) claim that various individual skills and group knowledge are required to deal with the abundance of knowledge and its increasing complexity in different areas, to have different approaches to issues and reveal alternative methods to solve these issues. There is no doubt that the emergence of information technology, growing data flows and the development of networks are related to knowledge management and the need to manage knowledge. In the model of Choo (1998), at the centre there is information which is collected and used for the organisation's operation, and in the model of Voehl and Harrington (2006) – knowledge. Many scholars (Voehl and Harrington 2006) agree that a knowledge management cycle is characterised by six stages: creation (people themselves develop new techniques and methods to do the job; it is also possible to develop methodologies and buy them from external sources), capturing (capturing of knowledge and its presentation in an understandable form), refinement (supplementing with tacit knowledge), storage (storage of knowledge in an understandable form so that it could be used by members of the organisation), update (knowledge must be updated, its accuracy and relevance verified), dissemination (new knowledge must be accessible to all members of the organisation) (Katinienė 2016). An integral knowledge management model presented by Girnienė (2014) distinguishes a strategic block, a knowledge management block and an innovation block (see Fig. 5). The knowledge management block includes five knowledge management stages: identification, acquisition, creation, sharing and storage.

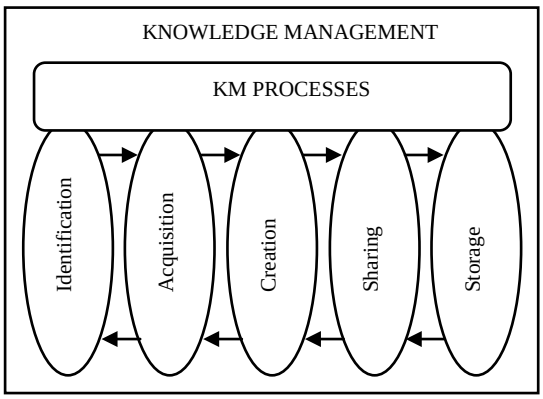

Fig. 5. *Knowledge management block (adapted by the author based on Girnienė 2014)*

Analysis of the knowledge management models presented by researchers raises some doubts about the sequence of processes. The first block in the knowledge management model cycle is identification. The available knowledge can help create and update other knowledge. Creation and updating are overlapping sets – when new knowledge is created, the existing knowledge is updated. Thus, it is appropriate to merge these blocks. Later knowledge is characterised by storage in an understandable manner so that it could be disseminated, reviewed and updated (see Fig. 6).

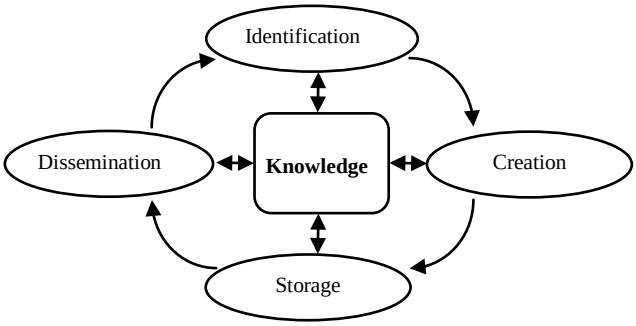

Fig. 6. *Knowledge management cycle in an organisation (designed by the author)*

At all stages of the model, knowledge movement is characterised by issues of leaking, depreciation, dependence and reliability (Table 5).

Table 5. *Problem areas of knowledge by stage of the knowledge management cycle (made by the author)*

Stage of the cycle	Knowledge processes	Problem area	Problem
Identification	Identified knowledge is in documents, videos and audio files, i.e. it is captured in an understandable form	Visibility	Not all knowledge is identified; some knowledge remains unnoticed
	Supplemented by tacit knowledge	Correctness	Depends on the subjective opinion and therefore knowledge may be false or correct
Creation	People create new techniques, methods and methodologies to do the job and create a new product or service	Leaking	Some ideas are rejected as unsuitable for the creation process and therefore such knowledge does not reach the appropriate subject
	The accuracy and relevance of knowledge should be verified	Reliability	Not always new knowledge is accurate. This is why there should be a certain time limit to check its suitability for the organisation and reliability
Storage	Storing knowledge in an understandable form so that it could be used by members of the organisation	Depreciation	Stored knowledge is getting old, i.e. it is replaced over the time
Dissemination	New knowledge must be accessible for all members of the organisation	Reliability, correctness, depreciation	When being disseminated, uniqueness is reducing and therefore knowledge can quickly lose its value.

Becerra, Lunnan, Huemer (2008) argue that the communication of explicit and tacit knowledge has different levels of trust and correctness. Many researchers (Dyer, Nobeoka 2000, Hall 2001, Kankanhalli *et al.* 2005, Wasko, Faraj 2005) claim that knowledge sharing affects the motivation of employees. Bock *et al.* (2005) and Lin (2007) empirically proved that mutual benefits had a positive effect on their attitude to knowledge sharing and influenced employees' intentions to engage into knowledge exchange. Chennamaneni *et al.* (2012) noticed that two-way communication promoted employees' desire to share knowledge. Dhanaraj *et al.* (2004) proved a significant impact of sharing tacit knowledge on sharing explicit knowledge. The employees' intention to share their tacit knowledge is perceived as a valuable resource which may have effect on their explicit knowledge. This is why the employees'

intention to share their tacit knowledge positively influences their intention to share their explicit knowledge. Thus, employees' intention to share tacit knowledge as know-how allows them to share explicit knowledge (Hau *et al.* 2013).

Nowadays, with technologies changing so rapidly, the issue of knowledge dissemination and ageing becomes more relevant, despite positive things that influence employees' attitude and desire to share knowledge and supplement the existing knowledge. When a man is an active participant and communicates knowledge to others, knowledge becomes known to all. Knowledge loses its value and uniqueness. It gets old as technology changes.

Conclusions

With the changing technologies and rapid market globalisation organisations are forced to respond and be able to manage changes, which requires knowledge – the most important resource of a knowledge society. It is a unique resource. It is expendable the same as material resources. Through communication and mutual cooperation employees use the existing knowledge and create new knowledge. The dynamism of activities, external environment requiring radical changes, employees' learning and knowledge play an important role in the success of an organisation.

There are different kinds of organisations. Every one of them has unique characteristics. However, the most popular concepts to describe the type of organisation are learning, creative, network and knowledge organisations. A learning organisation is prevailed by explicit knowledge as it promotes constant, uninterrupted teaching and learning. A creative organisation maintains a balance between production and creativity, trust, motivation, talent and creation of new knowledge. Regular contacts, sharing and communication of knowledge through networks are typical for a network organisation. To ensure benefits and effectiveness, a knowledge organisation combines knowledge/information databases and people's skills. Still, a knowledge organisation has characteristics of learning, creative and network organisations.

The need for knowledge starts with a man – unique and distinctive personal knowledge forms a unique personal culture, allowing the man to express creativity and create new knowledge. Personal knowledge is the main driving force of operation, facilitating development, the achievement of new objectives, and communication and cooperation with other people. Dealing with simple, personal or complex, multifaceted and global tasks requires sharing knowledge between scientific, business or public sector organisations and their members. Thus, knowledge is one of the most important and special resources, which, when in use, can bring significant benefits to a person, an organisation or the country's well-being.

A successful organisation must store and develop knowledge as well as facilitate knowledge sharing among employees. Knowledge has a cyclical nature, which makes it necessary to update it. A knowledge management model consists of four cycle stages: identification, creation, storage and dissemination. At stages of a knowledge management model, knowledge movement is characterised by issues of visibility, correctness, leaking, depreciation and reliability.

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