Based on existing developments in the field of risk management and knowledge management, a model, that combines modern approaches to risk management in order to preserve the knowledge of the organization, has been proposed. The model is presented in Figure 2.

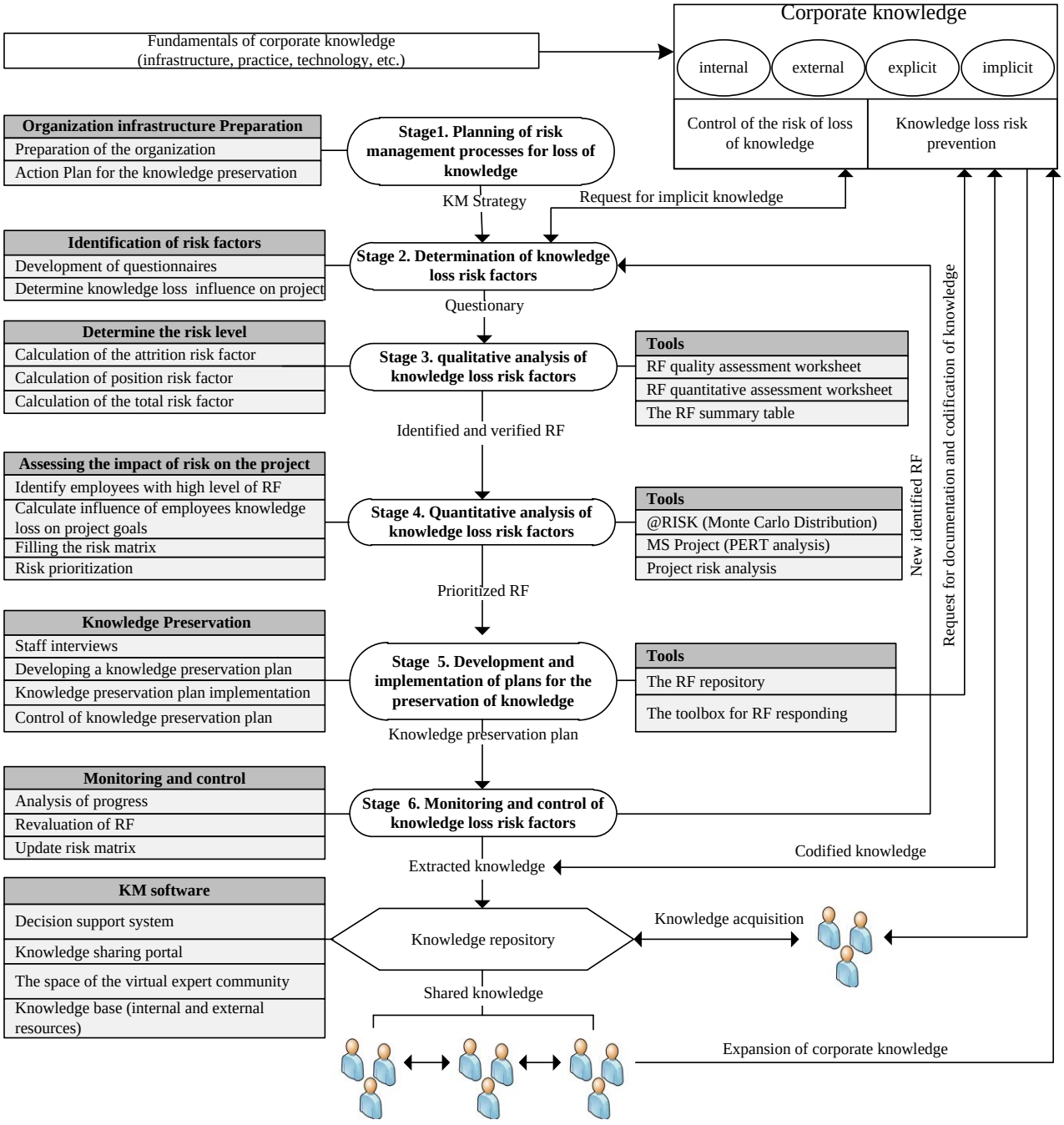


Figure 2. Integrated model for of knowledge loss risk management in the project environment

The study was based on the Tennessee Valley Authority (TVA) model, the knowledge management component, grounded on the Fraunhofer KM (Fraunhofer Institute) approach, and project risk management is based on the methodology of the Project Management Body of Knowledge (PMBOK). The new integrated model combines the components of the three above-mentioned models. In other words, the management of organizational knowledge is implemented through identification, prioritization, and impact on knowledge loss risk factors.

The model includes six key stages:
1) planning of risk management processes for loss of knowledge;
2) determination of knowledge loss risk factors;
3) qualitative analysis of knowledge loss risk factors;
4) quantitative analysis of knowledge loss risk factors;
5) development and implementation of plans for the preservation of knowledge;
6) monitoring and control of knowledge loss risk factors.
At the first stage, the main goal is to influence organizational culture, including for the purpose of obtaining support from the leadership, which is a necessary component for the successful implementation of the loss of knowledge risk management system.
The next step is to determine the characteristics of knowledge loss risk factors that have an impact on the project's objectives and its implementation. According to the TVA model, it is necessary to identify the overall risk factor for each worker based on 2 factors: 1) the expected attrition risk factor date, i.e. a risk factor that takes into account age, psychological state, career opportunities, etc.; 2) the position risk factor which reflects the degree of importance of the knowledge that the employee owns.
Qualitative analysis of knowledge loss risk factors is carried out by the direct manager and the project manager by filling in questionnaires that define responsibility, practical experience of employees, tasks according to job descriptions, indirect duties, repetitive tasks (for example, problem solving or troubleshooting), and other elements that affect the individual employee knowledge and its impact on project objectives. On the basis of the results of the qualitative assessment, the priorities of knowledge loss risk factors are set up.
The quantitative analysis of knowledge loss risk factors determines the impact of each knowledge loss risk factor by key project indicators (time, cost, and quality).
After that, shift to the next stage is made, i.e. developing and implementing a plan for preservation of knowledge.
Following the development and implementation of a knowledge preservation plan, the most important task is to monitor the process of preservation of knowledge, which includes assessment of the effectiveness of actions for the preservation of knowledge and the continuous updating of information on knowledge loss risk factors in the project.

6. Key Elements of the Model

The solution to this task is carried out using the Fraunhofer IPK Knowledge Management Model (Fraunhofer Institute of Mechanical Engineering and Automation) (Massingham, 2013), the risk management approach proposed in the Project Management Body of Knowledge (PMBOK, 2004) project management methodology and the knowledge loss risk assessment system of Tennessee Valley Authority (TVA). The main idea of the approach is to identify the risk of loss of knowledge for each project participant. On the basis of the identified common risk factor, prioritization of the risk level is performed and tools to prevent loss of knowledge are developed. According to the TVA model, it is necessary to identify the overall risk factor for each worker based on 2 factors: 1) the expected attrition risk factor date, i.e. a risk factor that takes into account age, psychological state, career opportunities, etc.; 2) the position risk factor which reflects the degree of importance of the knowledge that the employee owns.
Let's consider in detail six key stages of the model.
Stage 1. Planning of knowledge loss risk management processes.
The main goal of the stage implementation is to influence organizational culture, including for the purpose of obtaining support from the leadership, which is a necessary component for the successful implementation of the loss of knowledge risk management system. It is necessary to develop organizational policies on knowledge loss risk factors, including responsibility, motivation, etc. In addition, at this stage, an acceptable level of risk in the organization is defined (Choo et al., 2002); risk assessment methods are determined; a plan for implementing the strategy is worked out; a timetable and budget for its implementation is provided; stakeholder requirements are defined and support in decision-making is provided. As a result of this stage, the document "Project Description" is formed.
Stage 2. Definition of knowledge loss risk factors.
The second step is to determine the characteristics of knowledge loss risk factors that have an impact on the project's objectives and its implementation. The expected attrition risk factor date represents a period of time until the employee leaves his/her job through retirement, promotion, etc. The position risk factor is determined on the basis of the uniqueness or criticality of the employee's knowledge by establishing a scale of difficulty or the level of effort that must be made to replace an employee, providing a minimal impact on the results of the project (Hedlund, 1994). To determine the listed factors and their impact on project indicators, knowledge maps (Mertins et al., 2001) of project participants and questionnaires should be developed.

Stage 3. Qualitative analysis of knowledge loss risk factors.
The purpose of this phase is to identify the employees whose knowledge loss risk factors are the highest, that is, the greatest probability of loss of knowledge important for the project. The paper (Meister et al., 2000) notes that the risk value is calculated by multiplying the probability of occurrence of risk by its consequences. The expected attrition risk factor date is considered in the paper as probability (AR). As criteria for estimating the expected time of employee loss, the following criteria are used in Table 2.

Table 2. Attrition risk criteria

Criteria	Value
Losing human resources in current year or next year	5
Losing human resources in next 3 year	4
Losing human resources in next 4 year	3
Losing human resources in next 5 year	2
Losing human resources in next 6 year	1
Losing human resources in next seven years and more	0

In addition to determining the expected attrition risk factor date, it is necessary to define the consequences in the event of a risk (considered as a position risk in the paper). The second part of the questionnaire defines the criticality of knowledge for the purposes of the project, the time required for training a new employee, etc. An example of a ranking of criteria for assessing the position factor (PR) is given in Table 3.

Table 3. Position risk criteria

Criteria	Value
Critical or unique knowledge. Critical knowledge about main organizational processes. Specific organizational knowledge. Undocumented knowledge. Replacing this position requires 3-5 years to acquire the necessary experience and skills. There is no person in the organization who can take a post.	5
Critical skills and knowledge. Has knowledge that other workers have only partly. Part of the knowledge is documented. It takes 1 to 2 years to prepare a new specialist for the post.	4
Important fundamental knowledge and skills. Knowledge is documented. Similar knowledge is shared by other employees. It takes 6 to 12 months to prepare a new specialist for the post.	3
Knowledge and skills can be obtained in the process of performing the work. Work procedures are described in detail. Training programs have been developed for beginners who provide the opportunity to prepare an employee for a post in less than 6 months.	2
No additional training is required, the employee can quickly learn to perform the necessary tasks.	1

Criteria for assessing the position factor may take into account such elements as employee experience, responsibility, tasks according to job descriptions, indirect responsibilities, repetitive tasks (for example, problem solving or troubleshooting) and other elements that affect the individual employee's knowledge.
Thus, the overall risk factor (Ri) can be calculated as multiplication of the expected time of employee loss and the consequences of loss of employee.

$$R_i = AR \times PR. \qquad (1)$$

To calculate the overall risk factor for each employee, responsible persons must fill out a questionnaire, which determines, based on the above criteria, the expected attrition risk factor date and the criticality of his/her knowledge for the project.
The paper (Jennex et al., 2013) notes that the definition of knowledge loss risk factors of the project participants should take into account the views of both the direct manager and the project manager. This approach avoids misunderstandings regarding the level of qualification and uniqueness of the professional knowledge of project

participants. Taking into account this fact, the knowledge loss risk factor of a project team member is calculated according to the following formula:

$$RF_i = 0{,}6 \times R_{pm} + 0{,}4 \times R_m \,, \qquad (2)$$

where RF_i is the knowledge loss risk factor of a project team member;
R_{pm} is the results of interview of the project manager;
R_m is the results of interview of the direct manager;

The stage allows to rank employees by the level of uniqueness of knowledge and taking into account the expected attrition risk factor date. According to the results, participants can be divided into four groups by the importance of knowledge (Table 4).

Table 4. Criterion assessment of the project participant knowledge

Criterion	Groups	Risk response
20<RF≤25	Group 1. Extra-high level of importance.	Requires quick response within the time limit. Response methods: realization of the knowledge preservation plan, assessment of knowledge, mentoring and training process.
15<RF≤20	Group 2. High level of importance.	The development of a staffing plan for the implementation, methods and timing of replacement.
10<RF≤15	Group 3. Medium level of importance.	Requires a plan for replacing the required post. Development a training program for new staff.
5<RF≤10	Group 4. Low level of importance.	Requires setting tasks related to the position and the need for a new replacement.
1≤RF≤5	Group 5. Low-low level of importance.	Determination of responsibilities associated with the post.

The result of this phase provides an understanding of the overall picture of the knowledge of project participants, but it does not allow assessing how the loss of one or another knowledge influences key project indicators such as cost, duration and quality.

Stage 4. Quantitative analysis of knowledge loss risk factors.

This stage involves a statistical analysis of the consequences of the loss of knowledge of employees, the knowledge loss risk factor of which exceeds 15 points (Hedlund, 1994), that is, the knowledge that they possess is difficult to recover and can be lost in the near future. At this stage, the impact of each important knowledge loss risk factor on key project indicators (time, cost, and quality) will be determined on the basis of interviewing and expert review.

The next step at this stage is to determine the level of influence of critical knowledge loss risk factors on project indicators.

The stage is implemented by sensitivity analysis (Monte Carlo simulation), which can determine the probability of achieving the objectives of the project. On the basis of the obtained results, the project priorities can be updated. According to the results of simulations it is necessary to prioritize the processing of knowledge of project participants. After detailed qualitative and quantitative risk assessment, plans may be developed to preserve the most prioritized knowledge that may affect the outcome of the project.

Stage 5. Development and implementation of plans for the preservation of knowledge.

Upon completion of a qualitative and quantitative risk assessment, the next step is to reduce the risk of loss of knowledge of employees with a high knowledge loss risk factor. As noted by the author (Saha et al., 2016), actions that respond to risk factors can be divided into four main groups: reactions to avoid, transfer, mitigate or accept risk factors (Table 5).

Regarding the importance of risk, usually a reaction to it may include one or more reaction groups. Moreover, due to the need to create a certain groundwork for the manager to make a decision on maintaining employee knowledge, it is necessary to obtain sufficient information by interviewing a person with critical knowledge.

Table 5. Preventive measures for the knowledge preservation

Groups of response	Preventive measures
Establishment of a contract	Staff hiring or transferring Hiring part-time staff, contractors for project tasks
Mentoring	Conducting training on simulators Computerized training and use of educational videos Joint task accomplishment: mentoring, repetition, training Internship programs Mutual learning Thematic seminars
Reengineering	Improvement of processes Upgrading equipment Introduction of innovative technologies Creating an open space for improving communications Conducting a review of the projects being implemented
Codification	Documentation Updating existing knowledge Development of video instructions Performance Support Systems Standardization Providing access to document circulation (sharing folder, Intranet, etc.). Fixing the lessons learned
Other types of response	Temporary employees (on time contract) Carrying out part-time duties Financial motivation for creation Providing copyright protection Encouraging knowledge sharing and self-education Use of the bonus for continued work, with the purpose of preserving the employee of retirement age in the workplace

Stage 6. Monitoring and control of knowledge loss risk factors.
Following the development and implementation of a knowledge retention plan, the most important task is to monitor the process of preserving knowledge.
The most commonly used measures include:
1. Report on the process of implementing the plan for the preservation of knowledge.
2. Identification of positions for which reassessment or development of a knowledge retention plan is required.
3. Review of criteria for assessing knowledge preservation plans:
- forecasting of future probable depreciation of knowledge;
- review of a list of high priority items;
- definition of certain positions, where for the preservation of knowledge the next stage must be proceeded;
- completion of the procedures for the conservation of knowledge.
4. Assessment of the impact of the knowledge that has been removed on the performance of the organization.
5. Assessment of the effectiveness of knowledge conservation plans to achieve the objectives of the projects.
Thus, the proposed model allows to prevent the risk of loss of knowledge that adversely affects the project through the use of key approaches to knowledge management and risk management.

7. Case study

On the basis of the proposed knowledge loss risk management model was implemented in Tempus project "Interregional Network for Innovative Development of Ecosystems Technosphere Based on Micro- and Nanoobject Technologies - ECOTESY" (544498-TEMPUS-1-2013-1 - TEMPUS-JPHES). The goal of the project is to create a single comprehensive vertically integrated system of innovative development of ecosystems technosphere (studying – research – production – maintenance - utilization) while achieving synergetic effect by using the results of Tempus projects in the field of green technologies and innovations support: UNI4INNO (Innovations support), GREENCO (Green Computing), REGENLAW (Energy and Environmental Law) etc.

Critical knowledge loss leads to project quality decrease and affect the project schedule. Thus, the ECOTESY project aims to prevent the knowledge loss. The implementation of integrated approaches of KM and RM in ECOTESY project is focused on knowledge acquisition, preservation and dissemination within the project. In line with the steps identified in the model, knowledge preservation strategy that integrates knowledge management tools and risk management tools was implemented in ECOTESY project. Stages of the concept implementation meet the key elements of the proposed model.

Stage 1. Knowledge risk management planning

On this stage, the most important task was to obtain top management support in a project consortium, that includes 17 organizations (6 European, 4 Belarusian, 7 Ukrainian), including National Aerospace University “Kharkiv Aviation Institute”.

Stage 2. Identification of the RF.

Knowledge loss risk identification card was developed and sent to the units involved in the implementation of the pilot project. Cards were filled by a direct manager and project manager at the university. The results of the survey were processed by the team from the KM.

Stage 3. Qualitative assessment of the RF.

The most important element of qualitative risk analysis was the identification of RFs priority. For this purpose, the information obtained in the previous step was used to determine the general RF (formula 2) for each participant in the project team. Based on the calculation, a diagram was constructed (fig. 5a).Were identified 5 participants from the team, who exceeded 15 points in accordance with knowledge loss risk identification card. For these participants was calculated quantitative risk analysis and risk prioritization on the next stages.

Stage 4. Quantitative assessment of the RF.

The next step was a quantitative assessment of the RF impact on the pilot project indicators. Despite the RF, the expected duration of this project was estimated at about three years, and the project was at the initiation stage. At was necessary to analyze the effect of the RF on the main project indicators (quality, time and cost) as follow: the project budget and schedule were analyzed; was identified the list of project tasks that have the greatest impact on its duration and cost; the value of each RF for the project cost and schedule were determined (the analysis was carried out with the help of a questionnaire, which determines the cost of replacing the employee).

To obtain the function of the distribution for duration and cost of the project tasks, the Monte Carlo simulation method (using the @RISK software product) was used, and the result of 1000 simulation cycles (fig. 3). The simulation results obtained the project cost and duration in the case risk and define the distribution functions.

Figure 3. The screenshot of the of the expected duration simulation process

The obtained duration and cost distribution functions were used for simulation with the Primavera Risk Analysis software. The software product defined the project duration and cost, taking into accounts the effect of the RF for

each task. Next step was to determine the priorities of each RF in comparison with others. Simulation was proceed with the Simple Additive Weighting method.
The pilot project assumes that any increase in duration is twice as important as any change in the cost of the project. Thus, normalized weights of duration and cost were considered as:

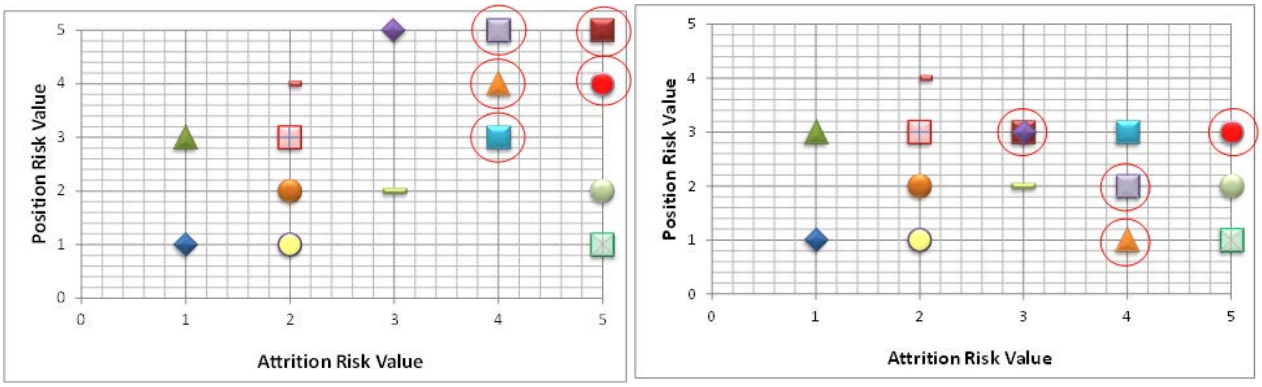
$$W = (time; cost) = (0,67; 033).$$

The main goal of this step is to define project participants, whose knowledge must be preserved to reduce the impact of their loss (table 6).

Table 6. Calculation and prioritization of the RF influence

Knowledge loss risk factor	Duration increase, %	Cost increase, %	Weighted sum	Risk priority
RF 1	7,88	10,01	25,78	2
RF 2	3,29	4,44	11,01	4
RF3	2,37	1,83	6,65	5
RF 4	0,66	17,37	18,68	3
RF 5	4,34	44,07	52,74	1

The quantitative meaning of the knowledge preservation priorities reflects participant's consistency as follow: RF 5, RF 1, RF4, RF 2, RF 3. After completing knowledge preservation activities for identified project participants, it is necessary to proceed to similar actions with employees who have from 10 to 15 points RF range.
5. Development and implementation of knowledge prevention plan.
Plan for knowledge preservation for employees with the highest RF was developed. After considering the results of employee's interview and the compilation of personal plan for the knowledge preservation (based on 10 proposed templates) were made several strategic decisions: 2 persons were recommended to take up the next level position, 3 junior specialist appointed to conduct training and mentoring for knowledge sharing.
6. Monitoring and evaluation of knowledge preservation process.
An important step in the development and implementation of knowledge preservation tools is the constant monitoring of RF. The frequency of reviewing the state of the RF depends on the staff turnover in the organization, the intensity of the work and the duration of the projects. In the pilot project, the results of KM model implementation are presented in Figure 4 (comparison of initial analysis and results).



a) initial analysis of project RFs b) result of model implementation
Figure 4. RF in pilot project as a result of actions on saving knowledge

The fig. 4 gives a good view of employees quantity adjustment who have a high degree of knowledge loss risk. Therefore, the proposed model provides a simple and effective way to reduce the risk of losing such knowledge of project participants, which may affect the project duration, quality and cost.

8. Conclusions

The paper has proposed a model that prevents the loss of critical knowledge of employees who, due to a number of reasons, can leave the organization (retirement, planned internal mobility, etc.). The integrated risk management model for loss of knowledge in the project environment combines knowledge and risk management components in the project, which allows identifying and preventing the risk of loss of knowledge in the project and thus reducing the negative impact on such key project indicators as cost, durability and quality.

The model is used as a tool to support management decision making, a tool for planning and assessing the loss of knowledge in projects. In addition, the model allows to solve key issues regarding large volumes of newly created knowledge, access to informal knowledge of experts, and exchange of knowledge and best practices within the project and within the organization.

The direction of further research is the development of tools for the preservation and dissemination of knowledge of those project participants who have high knowledge loss risk factors.

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