Cross-Disciplinary Approach for the Risk Assessment Ontology Design

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ABSTRACT

The article describes a cross-disciplinary approach to support the risk assessment process through an integrative tool based on a global ontology. The designed global ontology allows the risk identification and characterization, the related potential work accidents and/or diseases, and decides better for appropriate preventive/corrective measures (the risk assessment logical chain). The global ontology structure follow a matrix model with two dimensions: one related to the work system structure/components and the other related to the risk assessment logical chain. For the integrative tools, solutions there have been developed a risk assessment process modeling with the purpose of better explain and understand the relations in the risk assessment logical chain. In addition, a concept model was developed and implemented for the global ontology complete definition. Finally, an expert system and a web platform are presented as integrative tools for the risk assessment.

Keywords: Cross-Disciplinary Application, Expert System, Knowledge Based System, Knowledge Management, Occupational Health and Safety, Ontology, Risk Assessment/Evaluation, Web Platform

1. INTRODUCTION: ARGUMENTS FOR RISK ASSESSMENT IN THE PROFESSIONAL LIFE

Occupational health and safety risks are research subjects of many sciences because of the causes, processes, actors and effects diversity. Much more the work-related and occupational diseases are multi-factorial diseases among the working population that have a heavy impact on workers (employers themselves), enterprise (organizations communities) and society (family, local community). According to Hamalainen, Saarel, and Takala (2011, pp. 49-52) communicable diseases (28%), malignant neoplasm (25%), and circulatory diseases (21%) comprised 90% of all fatal work-related diseases based on calculated estimates for 2002 at the global level.

In the same context, there have been estimated that there are approximately 160 million
occupational diseases each year; 30-40% of these evolve as chronic diseases that determine permanent work incapacity. For these reasons, occupational diseases are considered as silent epidemics because they are hard to diagnose, are discovered late, and cannot assure the reversibility of individual’s health. Statistics show that 10-30% of the developed countries employees (workers) and 50-70% of the workers that belong to countries with low and medium economic development level are constantly exposed to occupational risk factors or work in non-ergonomic conditions (Hamalainen et al., 2011).

According to the recent EUROSTAT figures and the European Agency for Safety and Health at Work statistics, every year 5,580 people die in the European Union because of work-related accidents. In addition, the International Labour Organisation estimates that an additional 159,500 workers in the European Union die every year from occupational diseases. Considering both figures, it is estimated that every three-and-a-half minutes somebody in the European Union dies from work-related causes (European Commission, 2009, 2010).

Even in nowadays-economic crisis period, statistics related to work accidents, people injuries or health harmed in the workplace are not optimists; the European Risk Observatory and the European Agency for Safety and Health at Work Annual Report demonstrate this facts in the last years (European Commission, 2009, 2010; Steinbuka, Clemenceau, & De Norre, 2010). Workers, employers and managers of different levels need to be made aware of the risks that they face and how to manage them in accordance with the Community Strategy for Health and Safety at Work, for the period of 2007-2012, which aims to cut work-related accidents by a quarter across the European Union and to reduce occupational illnesses and diseases.

For each company, enterprise or organization the problem of risk factors analysis, evaluation and assessment, the study of their genesis (appearance, development, evolution, effects or impact) has to be a key activity for the professional life improvement and/or optimizations of work environment (“iceberg” model confirms that; Roughton & Mercurio, 2002). Nowadays the insurance companies have push organizations to sever measures/policies/ strategies implementation for diminishing the numbers of work accidents, diseases, illnesses or fatal exposures, fatal errors etc. that have impact on individual or collective workers (of all categories). The work insurance schemes can work as motivators where the costs of the insurance are perceived to be high by employers (more than 1% of the payroll) (European Agency for Safety and Health at Work, 2004, pp. 2-8).

The costs of the negative phenomena, associated with professional life or the work processes, are composed on one hand, by their direct effects on treatment and hospitalization of the affected human operators. On the other hand, the costs include the indirect effects regarding the lost of temporary or definite work capacity (considering that work accidents and occupational diseases imply costs of 3% from the GDP in the first case and about 20% in the last case, as average values for the European countries). Also, the social investigations done for the affected workers showed that the psychological stress experienced by them affect their family and also the collectivity (at organizational level) by affecting the health, and the wellbeing of other society members (in accordance with the documents and statistics provided by International Labor Organization).

In the last years, accepting the fact that at European level in the field of occupational health and safety there was important progresses reported, there are still some empirical practices and unsolved aspects. The costs of work accidents and occupational disease are still too high and do not split into equal proportions for all parties involved. The money lost by work absence is about one milliard Euros per year. The employers pay for the sick leave, the replacement of absent workers, for their loose productivity, and many of these costs are not covered by the work insurance system (Roughton & Mercurio, 2002). Small and middle size enterprises (SMEs) are mostly exposed to
these phenomena, having 82% from the total number of professional diseases and 90% from the deadly accidents (as average values for the European countries). Sectors like: constructions (civil engineering), agriculture, transportation and medical services involve a higher level of occupational/professional risks than the average, while the young workers, the emigrants, the older workers, and those who work in unsafe conditions are affected in a disproportionate way (European Commission, 2009, 2010).

The occupational health and safety European strategy (2007-2012) proposes a target of 25% reduction of work accidents and professional diseases. Therefore, the strategic action sets that must be implemented are: (1) The improvement and simplification of the existing laws and their better implementation in organizations’ practice by compulsory instruments, such as exchange of good practices; information exchange, sensitivity propaganda and better practices for employees/workers training and forming; (2) Defining and implementing of national strategies that should address most affected sectors; (3) Occupational health and safety activities have to be included in other fields of national and European politics (such as, education, public health, research) and the new synergies have to be identified; and (4) In the future, potential new risks have to be identified and evaluated by a detailed research plan, knowledge exchange and practical exploitation of the results (European Commission, 2010).

European Agency for Safety and Health at Work documents generate a large knowledge base for scientific research on health and safety by promoting best practices, statistics, publications, legislation, tendencies regarding research activity through the working groups formed at international, European, and national levels. Risk assessment is one of the most important topics of the Agency and it is the core activity of the health and safety management approach in an organization, in order to identify the appropriate preventive measures for the risk diminishing or elimination. Risk assessment is a key activity and a dynamic process that allow organizations to proactive act for managing workplaces risks.

At the European level, the most important legislation document related to risk assessment is the Framework Directive 89/391 (European Council, 1989). Based on this, there have been established a Guidance on risk assessment at work that describe and create the frameworks for risk assessment in organizations (European Commission, 1996). According to this document, “the purpose of carrying out a risk assessment is to enable the employer to take the measures necessary for the safety and health protection of workers.” These measures include prevention of occupational risks; providing information to workers; providing training to workers; providing the organization and mean to implement the necessary measures.

According to the European Union policies and strategies in the field of health and safety at work there are not fixed rules or procedure for the risk assessments. A common methodology is not yet established because of the large diversity of economic fields in which have to be applied (in direct relation with the object of the approach that is a specific man-machine-environment system, assimilated with a specific workplace) and the large diversity of the specific legislation relating to risk assessment in each member country. However, there are two principles when approaching a risk assessment: (1) to structure the assessment to ensure that all relevant hazards and risks are addressed (e.g., not to overlook tasks, such as cleaning, that might take place out of normal working hours, or ancillary departments such as waste compacting); and (2) when a risk is identified, to begin assessment from first principles by asking whether the risk can be eliminated.

According to the Guidance on risk assessment at work there have been established an approach based on a number of different steps (European Commission, 1996) as described briefly: (1) Establish a programme of risk assessment at work; (2) Structure the assessment (decide on the approach: geographical/functional/process/flow); (3) Collect information; (4) Identify hazards; (5) Identify those at risk; (6) Identify patterns of exposure among those at risk; (7) Evaluate the risks (the probability of
harm/severity of harm in actual circumstances); (8) Investigate options for eliminating or controlling risks; (9) Prioritize action and decide on control measures; (10) Implement controls; (11) Record the assessment; (12) Measure the action effectiveness; (13) Review if changes are introduced, or periodically; and (14) Monitor the risk assessment program.

For most economic sectors, organizations and especially small and medium-sized enterprises, a straightforward five-step approach (incorporating elements of risk management) are much more efficient for a risk assessment action (Table 1).

Besides this European framework, most of the modern organizations have integrated the risk assessment approaches and procedures into the complex matrix defined by the ISO 9000, ISO 14000 and ISO 18000 standards - quality, safety and environment management. Furthermore, the complex matrix has been extended with the integration of ISO 26000 (social responsibility) and ISO 31000 (risk management). Modern organizations with a commitment to managing risk know that implementing these standards can enable them to do so more effectively and therefore maximize opportunities and minimize losses in the course of achieving their objectives. Specialists examine the future ISO 31000 standard which will be a strategic-level document covering all forms of risk, including safety and the environment and it is expected to help industry and commerce, public and private, to confidently emerge from the crisis (Knight, 2007, 2009). The described standard framework is correlated with the scenario proposed by the Europe 2020 growth strategy for the coming decade.

There are many risk assessment tools and methodologies available (developed in each country in Europe and worldwide) to help enterprises and organizations assess their risks. The choice of method will depend on the workplace conditions (for example, the number of workers, the type of work activities and equipment, the particular features of the workplace and any specific risks), the assessor/evaluator ability to use a particular method (which he is familiar with) and the costs related to the implementation of a particular method and tool.

When a risk assessment process is initiating and develop in an organization, specialists have to have access to a large amount of data, information, knowledge, laws and regulations, and most to biographic databases with case studies, best practices. A good reference source is CISDOC database provided by the International Occupational Safety and Health Information Centre (CIS) of the International Labour Organization. The CIS bibliographic database contains about 70,000 citations of documents that deal with occupational accidents and diseases as well as ways of preventing them. The types of documents are: laws and regulations, chemical safety data sheets, training material, articles from periodical publications, books and standards. Every record contains a detailed bibliographic description, a full abstract

<table>
<thead>
<tr>
<th><strong>Step Approach</strong></th>
<th><strong>Description</strong></th>
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<tr>
<td>Step 1. Identifying hazards and those at risk</td>
<td>Looking for those things at work that have the potential to cause harm, and identifying workers who may be exposed to the hazards.</td>
</tr>
<tr>
<td>Step 2. Evaluating and prioritizing risks</td>
<td>Estimating the existing risks (the severity and probability of possible harm...) and prioritizing them in order of importance.</td>
</tr>
<tr>
<td>Step 3. Deciding on preventive action</td>
<td>Identifying the appropriate measures to eliminate or control the risks.</td>
</tr>
<tr>
<td>Step 4. Taking action</td>
<td>Putting in place the preventive and protective measures through a prioritization plan.</td>
</tr>
<tr>
<td>Step 5. Monitoring and reviewing</td>
<td>The assessment should be reviewed at regular intervals to ensure that it remains up to date.</td>
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Table 1. Basic steps for a risk assessment process development

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and indexing descriptors drawn from the CIS Thesaurus. The CISDOC database is updated on a continuous basis (International Labour Organization, 2011).

It is well recognized that the most common risk assessment tools are checklists, which are a useful tool to help identify hazards. Other kinds of risk assessment tools include guides, guidance documents, handbooks, brochures, questionnaires, and "interactive tools" (free interactive software, including downloadable applications, which are usually economic sector-specific). These tools can be either generic or branch/risk-specific. The European Agency for Safety and Health at Work has developed a risk assessment tools database with tools from all over Europe. These tools are free and available online using a specific search function. The database is regularly updated with new tools (European Agency for Safety and Health at Work, 2011).

During the last couple of years, specialists have been oriented their researches, studies for discovering or defining (adapt existing methods and tools) adequate risk assessment tools in the case of small and medium size enterprises, but the research community is scattered between many different disciplines and institutions. There is a lack of evaluation of intervention studies, both in terms of effect and practical applicability. However, there is sufficiently strong evidence to conclude that employees of small and medium size enterprises are subject to higher risks than the employees of larger ones and that small and medium size enterprise have difficulties in controlling risk management processes. The most effective preventive approaches seem to be simple and low cost solutions, disseminated through personal contact. It is important to develop future intervention research strategies, which study the complete intervention system: from the intermediaries through dissemination methods to the resulting preventive activities of the small and medium size enterprises (Stephens, Hickling, Gaskell, Burton, & Holland, 2004; Halse & Limborg, 2006; Gaskell, Hickling, & Stephens, 2007; Rosu, Dragoi, & Guran, 2009).

During 2010, the European Agency developed an Online interactive Risk Assessment tool (OiRA), which is the legacy of the Healthy Workplaces Campaign on Risk Assessment 2008-2009 and that has been designed to fulfill the lack of risk assessment tools for small and medium size enterprises. OiRA was inspired by the Dutch experience gained with RI&E tools that were among the first online risk assessment tools developed in Europe (European Agency for Safety and Health at Work, 2009). It is planned that the OiRA tool (which the Agency is making available free) will help many thousands of small and medium size companies across the European Union (EU27) to carry out risk assessments in a simple and cost-effective way. In 2011, the OiRA tool was official presented during the 19th World Congress on Safety and Health at work that was held in Istanbul, Turkey. Till now, there are modest results as possible applications (by potential users) of this tools: hairdresser in Cyprus and three other tools under development: public administration — working offices in Cyprus, transport/tourist in France and private security a tool that will be developed in co-operation by some OiRA project members.

In addition, it is promised an OiRA mobile application (soon (http://www.oiraproject.eu/).

The tools developed or underdeveloped till now, are very simple and potential users from other economic fields as construction, chemical engineering, manufacturing, hospitals etc. (where the risks assessment is much more complex) may doubt about the usefulness of OiRA.

Regarding the theoretical scientific background of the OiRA tools we have a doubt regarding the presented list of risk factors that are analyze or take into consideration during an assessment process (is the list complete? which is the detail degree of each risk class?). Also, from the existing guidance there are missing important methodological aspects. Another aspect that cannot be seen from the existing documents is related to the OiRA tools capacity to forecast a negative effect of a risk (by showing to the assessor/user the variety or all of potential effects in terms of possible work diseases or accidents).
From the brief overview of the background and the literature review regarding the risk assessment process related to professional life health and safety some conclusions can be made: (1) The legislative framework is well define and the tendencies for the risk assessment approaches in any type of organization (different by size or economic field) are marked by ISO 26000 (social responsibility) and ISO 31000 (risk management) standards. Each existing risk method is related to some specific directives, regulations, standards or laws; (2) the most common risk assessment tools are checklists. Many national and international organisms, associations or organization try to offer checklist models (with standard framework) to better support the risk assessment specialists in their work. In addition, via Internet there are available guides, guidance documents, handbooks, and brochures, databases with good practices, technical reports and legislation collections; and (3) There are no approaches based on knowledge management methods and tools or on modern information technologies for defining complete and complex risk assessment platform (with a wide applicability in any economic sector and any organization). This will be the niche of research and development proposed by the present article.

1.1. Brief Research Context Description

The present research results are connected to the project “Interdisciplinary researches for an occupational risk evaluation platform development with impact on the organizations’ health and safety culture” (CNCSIS, ID 1022, 2008 – 2011) in Romania. The project aim is to develop a decision-making tool that can better assist risk assessors. In addition, the research results will increase companies’ competitiveness by optimizing the resources dedicated to different management systems. Therefore, companies usually use the quality management on site (according to ISO 9000 requirements); they sometimes apply a safety and environmental management system (according to ISO 14000), but only a few companies apply integrated management systems (related to ISO 18000 and much more to ISO 26000 or ISO 31000).

The consequences are related to waste of money (additional costs) and human resources that can be avoided by an integrative approach like the one proposed in the present article. Therefore, the researches establish a cross-disciplinary methodology for risk assessment and an implementation model in terms of integrated management (related to health, safety and environment risk evaluation).

These preliminary results will be the background of an occupational risk assessment platform (as a web application) that is dedicated to those companies that usually allocate small budget to process management, especially the small and medium size enterprises (SMEs) (Draghici, Vacarescu, & Predpicianu, 2009; Dragoi, Draghici, Rosu, Radovici, & Cotet, 2010). This tool will provide the information access during all the working processes in order to integrative assess health, safety and environment aspects related to a specific work place/system. Therefore, we propose to design and develop a web application to use ontology in a collaborative environment (by integrating in an existing management information system the newly created facility).

1.2. Research Motivations and Objectives

Companies’ risk evaluators or assessors (managers of different hierarchical levels together with occupational health and safety specialists) need to know how to balance the contingency of risk with their specific contractual, financial, operational and organizational requirements. In order to achieve this balance, there have to be made a correct and complete risk identification and analysis. The risk management processes requires to identify different risks and exposures, and then formulate an effective risk management strategy to mitigate the potential for loss (Draghici et al., 2009; Dragoi et al., 2010). There has to be considered that occupational/professional risks assessment is an important part of
present business enterprise when concept as: sustainable workplaces or wellbeing at work are important debate issues between specialists. The complete risks list can be defined based on the existing available information and knowledge (as the CISDOC database is or other relevant resources on Internet). This can be then assimilated with a complete checklist, which can be used for the development of causes-effects analysis with the purpose of the work diseases and accidents database description. After the global effects description, based on the existing regulations and laws in a specific field of activity, there can be elaborate the corrective measures for the risk evolution in the specific work system.

Currently, there are different management models that companies can adopt to increase their competitiveness, as ISO 14000, OHSAS 18001 standards that can be considered as reference points for the environmental management process and for the management system specification for occupational health and safety in companies. The integration of these two aspects is very rare and limited to a formal process that means the existence of policies, manuals, procedures and registers unification (Fuertes, Casals, Gangoles, Forcada, & Roca, 2008).

The legal framework of our research is related to the following standards: the Directive 89/391/EC, the OHSAS 18001 and 18002:2007 standard, the Romanian Law for Work Safety and Health 319/2006 and other European standards that include recommendations for the risk assessment methodology of work health and safety (e.g., CEI 812/1985; EN 1050:2000; EN 12100:2003; BS 8800:1996 Annex D; etc.).

The present article proposes an approach for the integrated assessment (evaluation and analysis) of environmental, safety and health risks with the declared aim to better control these risks and reduce their impact upon the organization/work system processes. The main objectives of the research developed are: (1) To design and develop an ontology that represents the concept model based on the terms related to integrated health and safety evaluation (different risk aspects, impact related to work diseases and work accidents, preventive and corrective measures) - this will be also related to the risks evaluation factors that can occur in the work place environment (risks that can be transferred to related areas); and (2) To establish the structure/preliminary architecture of a decision making tool, based on the risk ontology for a complete and complex (integrative) risk evaluation process in the man (together with the work task subsystem) - machine - environment system - this will also support the implementation of the adequate, appropriate preventive measures.

2. THE RISK ASSESSMENT GLOBAL ONTOLOGY DESIGN

Any ontology defines a common vocabulary for researchers who need to share information in a domain (Noy & McGuinness, 2001). A widely used definition states that an ontology is a formal specification of a shared conceptualization (Gruber, 1993). It consists of concept definitions, relations and rules about a domain. Ontology can be used in knowledge based systems with the potential to employ inference and can be built based on artificial intelligent modeling techniques like frames and first-order logic, as well as based on description logic modeling techniques. Software engineering techniques can also be used to build ontologies (Gomez-Perez, Fernandez-Lopez, & Corcho, 2003; Dokas, 2007).

Initially, the ontology had two objectives: (1) to ensure a common understanding of specific terms describing risk factors, heath problems (from a medical perspective) and corrective measures (in terms of risk management), and research relevant to state-of-the-art in the field; and (2) to provide the structure of a complete knowledge map by consider the global system man (work task) – machine - environment. The goal of the knowledge map was to enable explicit charting of the mentioned issues to clearly define and locate each item and to develop a concise, extended data base with all risk factors, work accidents and illness, preven-
tive/corrective measures depiction (Molcho, Draghici, & Matta, 2007; Dragoi et al., 2010).

This research attempts to develop a global ontology focused on all the terms (different risks categories, impact related to work diseases and work accidents, preventive and corrective measures) related to the health and safety management, but also to the environmental management by considering the relationships that exist among them. This will generate facilities for a holistic process of risks (analysis, evaluation and minimizing their action where they can occur). To achieve the research objectives (Figure 1) there has been established a proposed research scenario based on a bottom-top approach.

The scenario consists of the following preliminary stages: (1) Knowledge capitalization and formalization regarding the occupational risk from the perspective of the interdisciplinary and systemic approach given by ergonomics; (2) Establishment of the occupational risk taxonomy structure; (3) Knowledge management approach support for the risk ontology definition by considering the work accidents genesis (risk factor—effects—prevention and corrective measures). These preliminary stages of the research have to be integrated in stage; and (4) Knowledge capitalization and formalization of risk factors for the proposed subsystems: human/man, work task, machine and work environment. A specific knowledge management software tools will MindManager support the risk ontology design, visualization and the final use of this research result. The presented approach for the global ontology development (design and building) is based on a matrix model that can be easy to understand (Table 2).

The matrix model of the global ontology definition has been detailed based on the process-modeling environment created by iGrafx /IDEF0 Integration DEFinition 0 (iGrafx, 2011).

![Figure 1. Schema of the proposed approached for the risk ontology design](image)

**Table 2. The matrix model for the risk assessment global ontology definition**

<table>
<thead>
<tr>
<th>Aspects of the Risk Assessment Procedure</th>
<th>Components/Subsystems of the Systemic Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk factors that are specific for the generated by:</td>
<td>Man Subsystems</td>
</tr>
<tr>
<td>Health and safety events that can occur in the:</td>
<td>Man Subsystems</td>
</tr>
<tr>
<td>Preventive, corrective or diminishing measures of risk factors that belong to:</td>
<td>Man Subsystems</td>
</tr>
</tbody>
</table>

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The graphical modeling approach has been developed in two stages. First development activity was related to the risk assessment process as an entity. The process modeling diagram in this case, consists of three distinguish ICOM boxes: A1 Risk factor; A2 the related Work diseases and/or accident; A3 The related corrective measures. In the second stage, the research and development activities were related to the risk assessment process as a system. In this case, the diagram consists of four distinguish processes: A1 Risk factor that are related or generated by the man subsystem, A2 Risk factor that are related or generated by the work task subsystem; A3 Risk factor that are related or generated by the machine subsystem; A4 Risk factor that are related or generated by the work environment subsystem. These modeling processes were the background (together with the global ontology definition) for the risk assessment specific tools development (see paragraph 3).

2.1. The Concept Model

A concept model was developed in order to understand/explain the main structure of the domain and to facilitate the development of the global ontology. Figure 2 shows the important terms and their relationships that should be included in the global ontology definition.

Figure 2. The concept model structure
The concept model is based on the Work Process/Activity (detailed description of the work place description together with the specific activities/process that is developed by the individual worker or by a group of workers). Each of these Work Process/Activity are simultaneously related to both environmental aspects (defined by the eco-management procedures and by the audit specific regulation, for example) and health and safety aspects (defined by the specific national laws and regulations). Because of these interactions, all the occupational risks are characterized and analyzed. Moreover, each risk category (related to different subsystems: human/man, work task, machine and work environment) has some related properties, and, based on the integrated analysis, the concept model will be more precise. Therefore and from the study of the valuation, environmental alternative technical solutions and health and safety alternative technical solutions are given, in order to reduce the risks impact upon the man (work task) - machine – environment system.

2.2. The Concept Model Implementation Process

The concept model implementation consists in the development of the ontology using appropriate software, in our case MindManager. The knowledge map, which is the basic taxonomy, built for the ontology structure was first structure and build – definition of a basic tree structure. Therefore, there has been described each item of the content that defines the background of the ontology and can be considered as similar to a database (Figure 3).

The ontology structure is based on the man (work task) - machine – environment systematic approach. For each subsystem there were identified and described (including relevant references): the occupational/professional risks, the work accidents and/or diseases and the

Figure 3. Screen of the general knowledge map built together with a particular note describing an item of the data base (in Romanian language because of the users’ environment specific)
preventive – corrective measures that can be implemented at the workplace level.

The design knowledge map and ontology will allow the analysis and optimization of the different work systems’ activities and interdependencies relations inside them by considering the technical, economic, social variables (integrative risk analysis). In addition, the proposed approach aims to collect the completely practical cases that can appear in different working systems regarding the occupational risks. Based on this, managers and work safety responsible persons can better analyze, evaluate and prevent the negative events of the working processes of their organization by not omitting some aspects or situations. In this context, safety responsible persons of the organizations (managers from different levels) can better define their strategies, policies and tactics and they can pro-actively act by investments in intelligence, learning, communication, and knowledge in order to develop the safety organization culture. A brief representation of the ontology structure is presented in Figure 4.

Only the first and the second level are shown because of the great/large number of branches related to the ontology knowledge map. The other levels/branches or subclasses are particularly built and developed depending of the considered sub-system. Then for each final item of the knowledge map there was defined a specific file (note) that included the detailed description of each item (risk factor, accident, disease, preventive and corrective measure) according to some existing regulation, with some examples and case studies for particular work systems depending of the industry type. These notes are definition elements of the database behind the knowledge map (Figure 3).

The risk assessment global ontology was first tested and validated inside the real economic environment of a company in the field of electric maintenance services. During the process, there have been identified and better characterized more risks that were collected by the evaluation process developed for the ISO 18001 company certification. Therefore, the risk assessment global ontology is a complex, innovative and useful tool, superior to the actual procedure for the occupational/professional risk analysis and evaluation. Future research projects will allow the extended of the experimental researches for the validation of the designed methodology and tool.

In practice then, for each occupational risk factor, standards and regulations have established precisely methods and tools for analysis and evaluation. These procedures of the experimental research will be described and will define a separate database that will be part of the web platform, too. The research approach facilitates future works for defining the risk evaluation platform that will be developed as a web platform (Figures 5 and 6). In Figure 5 is presented the intimate process of the risk evaluation (elementary action) that has to be developed by the evaluator.

The evaluation-analysis process of all risk categories related to the man (work task) – machine – environment system will have a double role. First, they will lead to the conclusions of the occupational risk diagnosis and to the

Figure 4. A basic structure of the risk ontology (the hierarchy tree)
elaboration of the technical and organizational solutions as preventive measures for the particular work place (in association with its specific work processes). Secondly, they will determine a knowledge capitalization (a library or database of case studies has been created) process in relation with the experience (wisdom) gained by the evaluators/assessors.
3. INTEGRATIVE TOOLS FOR RISK ASSESSMENT

The presented research approach facilitates the future development for defining the occupational risk evaluation platform, as an integrative tool based on the following results: the global risk assessment ontology, the process modeling of the risk assessment (as entity and as system) and the concept model development and implementation.

We recognize that the most common risk assessment tools are checklists has been transform into a much more efficient tool that is the global ontology. This will help not only for the hazards identification, but also for their characterization and evolution/impact estimation based on the available example of good practice, guidance documents, brochures, references database included in the ontology. The process modeling and the concept model support the better understanding of the risk assessment complexity - the complex interaction between the assessor, the organization management and the man (work task) – machine – environment system where the action is taking place. These preliminary research results are convergent to a adequate behavior of the risk assessors and their teams (e.g., risk mitigation, preventive, pro-active behavior, etc.).

Finally, the global ontology, the process modeling and the concept model design are able to support the design and development of an integrative tool for the risk assessment, which can be a universal/general one (not economic sector-specific and not organization/system size or type specific). In this context, there have been identified two possible solution of development.

3.1. An Expert System for the Risk Assessment Process

The first development was for an expert system design using the VP-Expert generator (version 2.1 – Educational Version). Production rules determine the knowledge representation model used. In the PRA.KBS knowledge base, there are if-then structure rules. The established know-
edge base rules were: rules for awarding point’s variables; rules for calculation of the partial scores and total score and rules for probability and severity of consequences assessment; risk arising from hazards in accordance with the total score obtained. For all variables there were assign 0 value, if the hazard exist (the answer from general checklist is YES) or 1 if hazard does not exist (the answer from general checklist is NO). Each value has an importance expressed by a factor with predetermined values (0 or 1). For all variables, the pondered factors must be introduced manually by the assessor/user during to knowledge base interrogation process (Rusu & Dragoi, 2011; Dragoi, Draghi, Rosu, Radovici, & Cotet, 2011).

After querying, the knowledge base will be displayed to evaluate the outcome of risk assessment conclusion and explanations on the likelihood and severity of injury in terms of consequences. Depending on the total score obtained and taking into account the probability and severity of consequences risk arising from hazards are evaluated - it may be small, medium or high. There have been considered the risk level depending on probability and severity of consequences as follows: small risk, medium risk and high risk (high risk is unacceptable and small/medium risks are acceptable). If the risk is identified as unacceptable (height or dangerous) some actions must be taken immediately for diminishing or elimination. If risk is identified as acceptable (small or medium / average) is recommended a plan of action to reduce it or to ensure that it will not evolve - remain at the same level. Corrective, prevention or protection measures that have to be implemented in the organization / work system are focus to eliminate or reduce the danger through organizational measures or use of collective and/or individual protection equipment. It is recommended a risk reassessment process of the activity system/sector after the implementation of these measures and to compare this result with those obtained at first evaluation, in order to verify the implemented measures effectiveness (Rusu & Dragoi, 2011; Dragoi et al., 2011).
3.2. Web Platform for the Risk Assessment Process

The second development process is related to a web platform design that can easily support the risk assessment processes in different organizations. The preliminary knowledge capitalization and formalization (described as the global risk assessment ontology) were transferred as knowledge objects in the new web platform. These were associated with an on-line questionnaire that will cumulate the results of the risk evaluation - the evaluator/assessor/user has to follow all the items of the defined knowledge management system and decide if the risk exists or not in the analyzed work system.

The information system design process was developed using the facilities offered by WampServer software, 2.1e version from 07.01.2011 that includes: Apache 2.2.17; Php 5.3.5; Mysql 5.5.8; XDebug 2.1.0-5.3-vc6; XDC 1.5; PhpMyadmin 3.3.9; SQLBuddy 1.3.2; webGrind 1.0. The web platform for the risk assessment was mainly structure as the global ontology is. The RISK, EFFECTS (occupational health and safety problems) and the MEASURES data bases were developed through the knowledge capitalization and formalization done for the global ontology. The web platform has a user friendly interface that allows: step-by-step assessment procedure by follow the work system structure (man/work task – machine – environment system has to be described in detail – comments are included manually) and follow the data bases RISK, EFFECTS, and MEASURES (in a logical scenario. Effects and corrective measures are filtered as the user/assessor selects a particular existing risk in the analysis work system).

The web platform allow saving partial data/information of the analysis (when the risk assessment process take place in several days) and the visualization of different steps of the assessment process (using the BACK button). Finally, after the risk assessment process is done, a Report can be generated, visualizing and then printed.

4. CONCLUSION

The paper presents a cross-disciplinary approach for occupational/professional risks assessment integrative tools development.

Using relevant references, there have been shown some preliminary considerations regarding the importance of the health and safety problems in companies/organizations to offer arguments of the proposed approach. It is clear that the European Agency for Safety and Health at Work has a coherent strategy and guidelines for improving the wellbeing at work. In addition, the legislative context offer by the ISO 9000 (quality management), ISO 14000 (safety management), ISO 18000 (environment management) standards and then by ISO 26000 (social responsibility) and ISO 31000 (risk management) standards are convergent to the Europe 2020 growth strategy for the coming decade.

In the scientific field of research regarding risk assessment specialists have been oriented their researches, studies for discovering or defining (adapt existing methods and tools) adequate risk assessment tools in the case of small and medium size enterprises, but the research community is scattered between many different disciplines and institutions. It is well recognize that the most common risk assessment tools are checklists (many models, drafts and template are offer by specialized research institutes or academic partners), which are useful tool to help identify hazards. Other kinds of risk assessment tools include guides, guidance documents, handbooks, brochures, questionnaires, and simple software tools (sometimes as free interactive software, including downloadable applications, which are usually economic sector-specific).

We can conclude that a integrative general application is not yet available to support the risk assessment process (in different work systems that belong to different organizations).

In the second part of the article, there have been described the research stages for building the risk assessment global ontology based on a cross-disciplinary approach. The global
ontology is based on a design taxonomy that consists of the following inventories: risk factor, work diseases/accidents related to each risk factor and the possible and allowed prevention or corrective measures (the risk assessment logical chain). This description was structured for the corresponding part of the man (work task) – machine – environment system and so, a matrix model of the global ontology has been defined. Its development was done using MindManager software. For the integrative tools, solutions there have been developed a risk assessment process modeling (as entity and as system, using iGrafx/IDEF0) with the purpose of better explain and understand the relations in the risk assessment logical chain. In addition, a concept model was developed and implemented for the global ontology complete definition, implementation and visualization.

The global risk assessment ontology was considered for the integrative tools development as a decision-making support used for the risk analysis and evaluation process, particularly in SMEs. Two solutions were described in part three of the present article: an expert system and a web platform. These tools will increase the efficiency of such evaluation processes and will be much closer to the preventive strategy imposed by the new strategy adopted in Europe in the field of Security and Occupational Health.

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