A model for product risk estimation through corporate memory and techniques integration

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Abstract: Aim of this paper is to enhance product risk estimation by providing an integrated model. The similarity of "technical" and "managerial" risk management methods is identified and there is an effort to compromise two of the most known and widely accepted ones, the FMECA (Failure Modes, Effects and Criticality Analysis) and the PMI (Project Management Institute) risk processes. Moreover, the paper suggests that one of the most important factors for an efficient risk management process implementation is the maintaining of a corporate memory. The information existing in the corporate memory feeds a risk estimation algorithm, which provides a common, for "technical" and "managerial" risk management methods, index of the product risk.

Key-Words: product risk, risk management, corporate memory, risk algorithm

1 Introduction

This paper presents a model for product risk estimation. The concept that has been followed in order the algorithm supporting the model to be produced, was based on the similarities that have been identified in all basic and widely accepted risk management methodologies. Whether "technical" or "managerial" risk management methodologies are based on the same principles thus they could be merged. The methodologies that have been examined here are the FMECA (Failure Modes, Effects and Criticality Analysis) and the PMI (Project Management Institute) risk processes.

The model, adopts the maintenance of a kind of memory, which is called corporate memory since its purpose is to track the risks that have been identified in the past in a specific enterprise or field of business. The main goal is to arm the enterprise with the knowledge and the experience acquired from the past concerning the product risk.

The rest of this paper is organised as follows: In Section 2 the problem of the study is formulated. The need of a common risk management process is argued and the basic methodologies that were used are analysed. The method proposed for the solution problem is described in Section 3. The benefits from the use of a risk management corporate memory are enlighten and the proposed algorithm of the model is presented. In Section 4 the conclusions and opportunities for further research in the topic are discussed.

2 Problem Formulation

Risk knowledge is fuzzy, unstructured, insufficient, tacit (in people minds only for example), forgotten as a solved ancient history, transformed afterwards, insufficiently organised and not or incompletely catalogued, underestimated, registered in heterogeneous information systems in the company, or even secretive [1].

However, risk is the key factor for product failure and should be confronted with great care and furthermore, it should be regarded as a strategic competitive factor [3]. In this paper two of the most

representative methodologies for "technical" and "managerial" risk management, respectively, have been selected and are presented right afterwards.

2.1 FMECA methodology

As written by Dhillon [4], Failure Modes and Effect Analysis is an outstanding tool for the design and analysis of engineering systems. It may simply be described as an approach to perform analysis of each potential failure mode in a system so as to study the potential effects of such a failure to the system itself. The method is an enhancement of Failure Analysis, which has been developed by the U.S Navy in order to establish a mechanism for reliability control over the detail design effort [5]. Nowadays, FMECA is widely used in aerospace, defense and nuclear power generation, as well as in many other complex systems, covering the technical part of risk management. **Figure 1** presents the steps that should be followed in order to perform the FMECA.

2.2 PMI methodology

On the other hand, each system or product contains a "managerial" risk apart from the pure technical

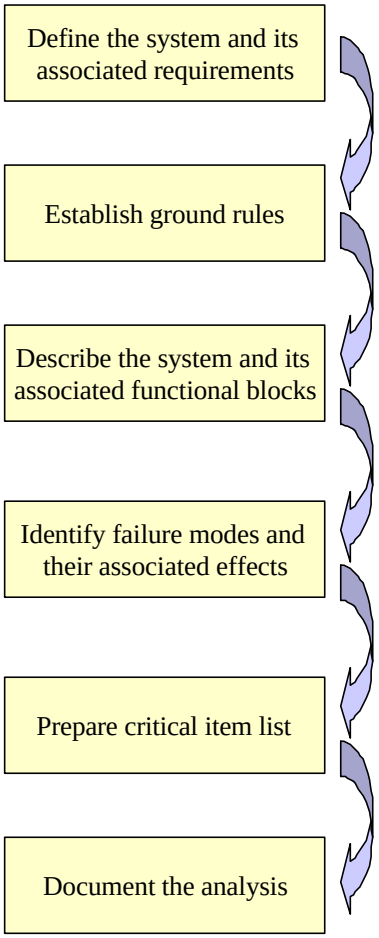

Fig. 1: FMECA process steps

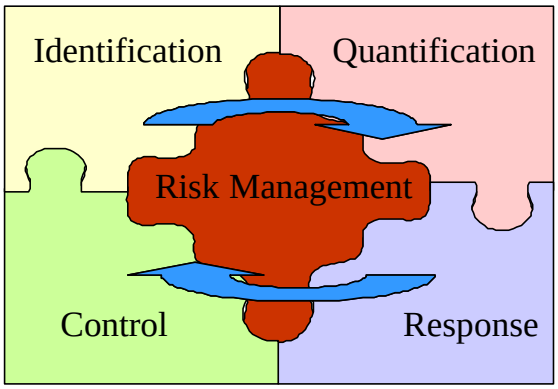

Fig. 2: PMI risk management steps

one. Since the production of more and more industries becomes project based, probably the best methodology to be followed in order to cope with this type of risk is the one that is proposed by the Project Management Institute [7]. **Figure 2** presents the steps for risk management that are proposed by the PMI.

It is a self-proving fact that **Fig.1** and **Fig.2** are in general the same process where the product or project manager are assigned the responsibility of

- investigating and revealing all the potential risks
- evaluate their importance (both methods use probability of appearance and potential consequences)
- decide what are the important risks that should be dealt with first
- follow up the overall process

3 Problem Solution

3.1 Common Risk Management Approach

Based on the aforementioned observations, it can be concluded that a common procedure for technical and managerial risks may be applied. As earlier mentioned, a basic factor for an efficient management of risk is the corporate memory. The Risk Management Corporate Memory (RMCM) supports corporate knowledge management of risk at business level [1]. Risks are organised into categories and an organisational risk management "referential" is constructed. The referential is consisted of all the risks concerning product development and have been identified in the enterprise, structured as shown in **Fig. 3**. Depending on the available information, a risk can be described in two different ways [6], a short and a long one.

In **Fig. 3**, each block represents an ontology related to risk. Each ontology is described by a specific characteristic, appearing in the elliptic scheme. More precisely the definitions are described below (adaptation from [2]):

- risk is a hazard or opportunity for the product. Risk severity is described by its exposure. The Exposure is calculated by taking into account the probability of the cause(s) and the gravity of impact(s) related to the risk (see Algorithm).
- cause is any uncertain event that may lead to the appearance of the risk and it is described by its probability of occurrence. A risk might have several causes.
- impact is the effect of the risk on the product or system and it is described by its gravity. A risk might have several impacts.
- Action is the way in which the product manager can cope with the risk and it is described by its cost. Actions are either preventive or corrective. Preventive actions are those who aim at the probability of occurrence of the cause and corrective those that aim at the gravity of the impact.

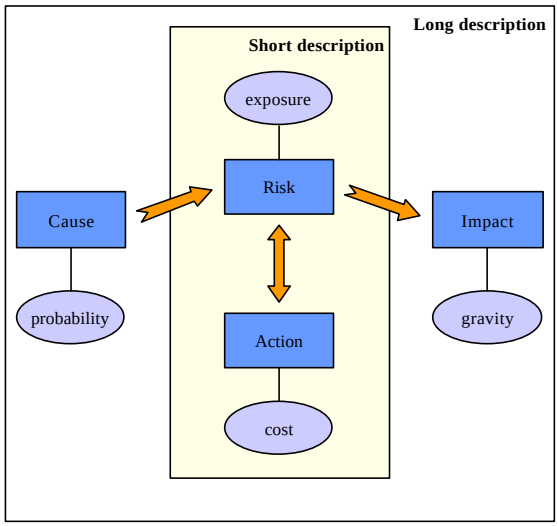

Fig. 3: Risk structure

The short way of describing a risk is to give just its exposure, most of the times coming from experts' opinion. Possible actions to mitigate the risk are also referenced.

The long way of describing a risk is by taking into account a more complete reasoning mode about the risk, called the complete causal chain. The complete causal chain is composed of risk, risk cause(s), risk impact(s) plus the action(s) to mitigate the risk. All the important information about the causal chain is stored in the RMCM in the form of a risk sheet [3].

3.2 Proposed Procedure

The proposed procedure is divided into five basic steps. The identification of risks, which is the first step, is based on the risk referential. The referential is reviewed and the risks that can be related to the product under investigation are selected. Moreover, new risks that are identified for the first time in the current product are also taken into account and enhance thereafter the referential.

The product manager is entirely in charge of the risk identification. The referential is used as an auxiliary help and the product manager is authorised to adapt it to his own context. In other words, the referential aids the product manager to reuse the knowledge existing in the referential. Identification of risks associated to a specific product can be made in several ways (by list, category or product element), depending on the level of existing knowledge. The existing Knowledge is organised in two dimensions. The first one concerns the amount of information, which is the level of detail for a risk (short or long description). The second dimension concerns the organisation of Knowledge. There are three levels of organisation. The first one, where there is only an unstructured list of risks, the second, where the risks are classified into categories such as managerial, financial, etc. and the last and most meaningful, where risks are attached to a specific product element such as a specific technical item or a function, etc.

The second step of the procedure is the assessment, which is based on a scale of risk. Scale parameterisation should be specific to each company. For instance, the highest level of risk could be estimated in human deaths in one case or millions of Euros in another. In the model presented in this paper, the scale is divided into two major sub-scales in order to be as much adaptable to specific industrial needs as possible. The first sub-scale is quantitative, expressed in terms of money and the other one is qualitative, based on a specific indicator. The model covers two basic needs of a company:

- It gives the possibility to describe the risk in terms of money. This is a benefit for the company as the risk could be compared to ROI measures. Moreover, bank, loans and financing, needs terms of money to proceed.
- On the other hand, most companies use qualitative systems because it is faster and easier to produce and it does not require so detailed information. However, it lucks processing capabilities and it boxes up less information.

Risks are considered either as hazards or opportunities. The cumulative effects of uncertain occurrences, which affect the product or the related system positively, are considered as opportunities

(positive risks). Events with potential for harmful consequences to the design, operation or environment of the product or system are considered as hazards (negative risks).
Knowledge state and knowledge progress about values of risks (i.e. first estimation at the beginning of the design, second after the implementation of a mitigation action, third return from experience, etc) are managed in the method presented, within three states which describe cause's, impact's and risk's assessment:

- The estimated value is the evaluation that exists in the referential at the beginning of the design process concerning the causal chain element in regard to the specific product.
- The initial value – before any mitigation action has been implemented is the product manager's opinion at the beginning of the design process, after taking into account the referential about the specific causal element.
- The reduced value is the estimation for the causal chain element after the implementation of mitigation action(s). The product manager fills in this value during the design or development process.

When the evaluation of the identified risks is completed a global exposure for each product is calculated. In that way, each product ends up with two indexes. The first is the cumulative result of the money scale (overall calculations can be done only when numeric information exists) and the second is a list of the qualitative assessed risks prioritised by their linguistic exposure (high, medium, low).
The manager in charge, based on these two indexes can make the comparison of the existing product solutions, if there are more than one.
The third step is risk prioritisation, which is judged from their exposure. The prioritisation is a descending sorting of exposures. When the quantitative scale (exposure in money) is used, the Product Manager is responsible for determining an exposure threshold alarm. This threshold is used to express the limit above which risks are regarded as important.
When the qualitative scale is used, three different results for the exposure are given. Prioritisation is an order of "unacceptable"(high), "to be examined"(medium) or "non important" (low) risks.
Risk mitigation, which is the fourth step of the procedure, is the way that has to be followed in order to minimise negative risks and maximise the positive ones. The important risks (unacceptable – to be examined) that occurred after the assessment step should be closely examined and treated, by defining the appropriate mitigation actions. An action can have affect on a cause of a risk – by reducing (or increasing for opportunities) its probability of occurrence - or on an impact – by reducing (or increasing for opportunities) its gravity. Product Manager has the responsibility to evaluate the possible actions and judge for their effectiveness in regard to their cost.
The last step is Risk follow-up during the design or development phase. There are many cases where risk exposure changes during the evolution of the design or development of a product. Aim of the Follow Up procedure is the updating of information concerning the risk causal chain (risk, cause, impact and actions), as well as the monitoring of the efficiency of mitigation actions.

3.3 The algorithm

The scope of this part of the paper is to describe the algorithm used for the implementation of the model concerning the product risk estimation. As stated earlier, the assessment of risk and consequently the algorithm is distinguished into quantitative and qualitative forms, as described below.
As far as the quantitative assessment is concerned, the method provides the calculation of the estimated, initial and reduced exposure of each risk. Each impact and risk is expressed quantitatively in terms of money.
The exposure of a risk *(estimated, initial or reduced)* is calculated by the multiplication of "cause probability" times "impact gravity". In case a specific risk is linked with more than one cause then the "cause probability" is calculated by using the appropriate probabilities laws [6]. As far as this algorithm is concerned, the "cause probability" is calculated by the eqn (1):

$$P = P_1 \cup P_2 \cup \ldots P_n = 1 - \prod_{i=1}^{n}(1-P_i) \qquad (1)$$

Where, P_i is the probability of occurrence of the i-th cause, for i=1,2,..,n
and $0 \le P_i \le 1$.
For n=2 the eqn (1) reduces to

$$P_1 \cup P_2 = P_1 + P_2 - P_1 P_2 \qquad (2)$$

In case a specific risk is linked with more than one impact, the "impact gravity" is the sum gravity of the impacts linked to the risk, as follows:

$$G = \sum_{i=1}^{n} G_i \qquad (3)$$

Where, G_i is the gravity of the i-th impact, for i=1,…,n

Thus, in general each type of exposure is being calculated by using the following equations:

Estimated exposure: $E_E = P_E * G_E$ (4)

Where, P_E: cause estimated probability (using eqn (1)), G_E: impact estimated gravity (using eqn (3))

Initial exposure: $E_I = P_I * G_I$ (5)

Where, P_I: cause initial probability (using eqn (1)), G_I: impact initial gravity (using eqn (3))

Reduced exposure: $E_R = P_R * G_R$ (6)

Where, P_R: cause reduced probability (using eqn (1)), G_R: impact reduced gravity (using eqn (3))

Concerning the calculation of the global exposures for a specific product the following equations are used:

Total Initial Exposure: $TIE = \sum_{i=1}^{n} E_{Ii}$ (7)

Where,
E_{Ii} : the initial exposure of the i- th risk linked to a specific proposal, for i=1,…,n

Total Reduced Exposure: $TRE = \sum_{i=1}^{n} E_{Ri}$ (8)

Where, E_{Ri} : the reduced exposure of the i- th risk linked to a specific proposal, for i=1,…,n
As far as the qualitative assessment is concerned, a 5-scale measurement (suggestively: very high, high, medium, low and very low) has been chosen to be used. The qualitative scale will be used if the product manager is not able or does not want to estimate the risk in terms of money. Each risk exposure will be assigned according to the matrix of **Fig.4**, where, the probability of the cause and the gravity of the impact will be expressed by one of the linguistic values (Very low, Low, Medium, High, Very high).

4 Conclusion – Further research

This paper presented an integrated model covering the needs of product risk estimation. The two most widely applied methodologies of risk management have been reviewed and it has been shown that they follow a very similar approach. The concept of the development of a Risk Management Corporate Memory has been proposed and the model was completed with an algorithm, able to provide an index of the overall risk exposure. Based on this index, the Product Manager may decide which is the best solution among different possible products or whether the risk exposure is acceptable or not for a specific product.
Further research should take place in the field of Knowledge Management in order the appropriate techniques of gathering information for the Risk Management Corporate Memory to be revealed.

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Probability	**Exposure**				
Very high	MEDIUM	MEDIUM	HIGH	HIGH	HIGH
High	LOW	MEDIUM	MEDIUM	HIGH	HIGH
Medium	LOW	MEDIUM	MEDIUM	MEDIUM	HIGH
Low	LOW	LOW	MEDIUM	MEDIUM	MEDIUM
Very low	LOW	LOW	LOW	LOW	MEDIUM
	very low	low	medium	high	Very high
	Gravity				

Fig. 4: Risk Matrix