A Fuzzy Risk Assessment Model (FRAM) for Risk Management (RM)

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Abstract

This study deals with the application of fuzzy logic reasoning to develop a Fuzzy Risk Assessment model i.e. FRAM to enhance the Risk Assessment (RA) process while considering uncertainties in each phase of RA. The main advantage of using fuzzy reasoning approach is limitations of subjectivity in RA.

In this study a Matlab Simulink model has been build that can effectively estimate the amount of Risk involved under a particular set of situations. FRAM provides a flexible framework built on the top of experience of experts which can prove to be an effective control system for regular RA in an organization.

1.0 Introduction

One of the most important and complicated task of Project Manager is to make effective decisions that could ultimately improves efficiency of Organization. The factors that adversely affect the decisions of Project Manager are Risks associated with the Project. Risk can be defined as, "the chance that an undesirable event will occur and the consequences of all its possible outcomes". Risk therefore can be conceptually defined as the function of Probability/Likelihood of occurrence of the event and Severity of the event occurring i.e. R=f (Probability, Severity) [1].

Estimating risk involves identifying the events that present hazards and produce risk, communicating the magnitude of the consequences associated with these events and estimating the likelihood of a given risk[2].Since probability of likelihood and consequence of severity are not directly measurable, therefore risks are difficult to measure in crisp terms. Fuzzy logic approach provides a new methodology to deal with these attributes that could only be estimated since exact values are impossible to determine.

This paper is described in six parts viz Part 1 gives Introduction. Part 2 explains Risk Management and Risk Assessment. Part 3 defines the concept of Fuzzy Risk Management. Part 4 shows Modelling and Simulations. Part 5 and Part 6 includes Conclusion and References respectively.

2.0 Risk Management (RM) and Risk Assessment (RA)

RM is the identification, assessment, and prioritization of risks, defined as "the effects of uncertainty of objectives, whether positive or negative, followed by the coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events"[3]. RM generally comprises of the following sequences:

(a) Identify/ Characterize threats.
(b) Assess the vulnerability of critical assets to specific threats.
(c) Determine risk.
(d) Identify ways to reduce risks and
(e) Prioritize risk reduction measures based on strategy.

The different phases/stages of the RM process are shown in figure 1.0

Once risks have been identified, they must then be assessed as to their probability of occurrence and severity of impact. RA can be defined as the process of estimating the possibility that a particular event may occur under a given set of circumstances [4]. RA can be considered as the most important and crucial step in RM as it provides a scientific basis for making decisions [5]. Bad implementation of risk analysis can lead to a subjective behaviour of a whole analysis with consecutive unclear results [11].

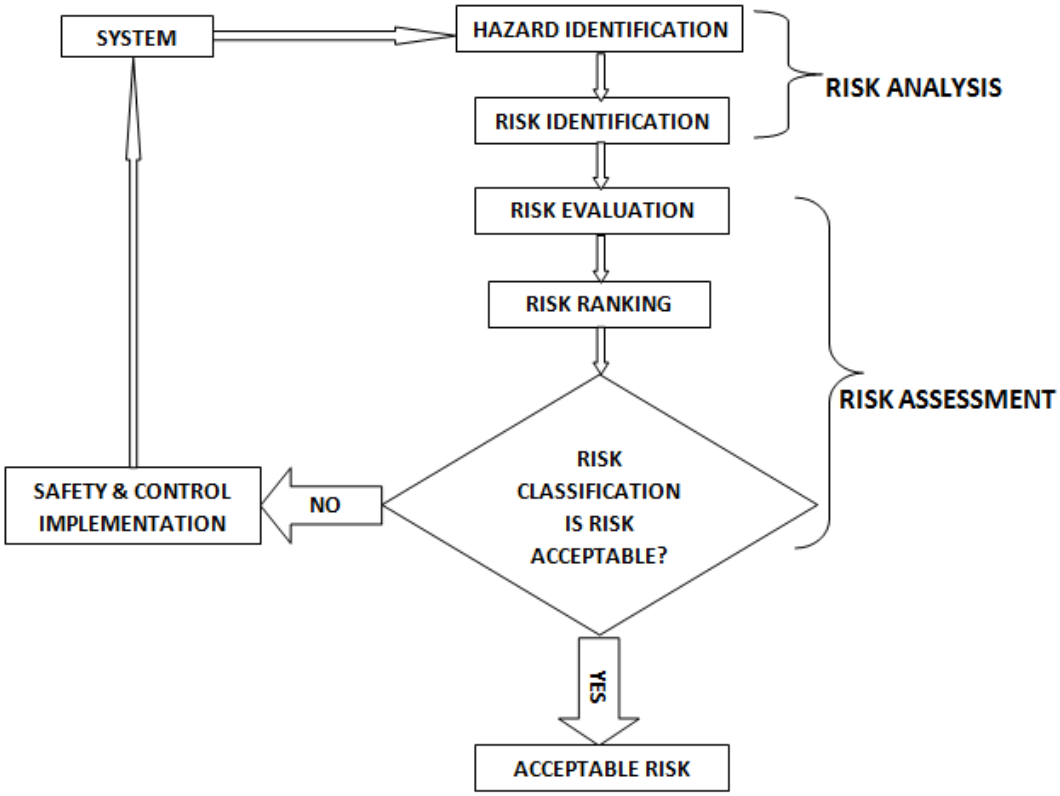

Figure 1.0 various stages/phases of RM process

If we look at the figure 1.0 then we can see that in RM decisions are made about whether an assessed risk needs to be managed or not and the means required for accomplishing that management.

3.0 Fuzzy Risk Management

Risk Management is a complex, multi-criteria and multi-parametrical system full of uncertainties and vagueness [6]. Fuzzy set theory not only helps in managing these complex and uncertain environment but also gives a user friendly visualization of the system construction and working model. Traditionally the probabilistic approach was mostly used in RA but, when some experts realised that probabilistic models could fail to provide satisfactory description of phenomenon application of fuzzy logic started to be more common[2][10].

In fuzzy based risk management models the risk and its attributes i.e. probability and severity are fuzzified because of their uncertain or linguistic representation. Furthermore the risk management and risk level calculation statements are represented in the form of if premises then conclusion rule forms, and the risk factor calculation or output decision (summarized output) is obtained using fuzzy approximate reasoning methods [7].

3.1 Design of FRAM using 'Matlab'

As stated earlier Risk can be defined as the function of Probability/Likelihood of occurrence of event and Severity of event occurring therefore, an Overview of FRAM is shown in figure 1.2

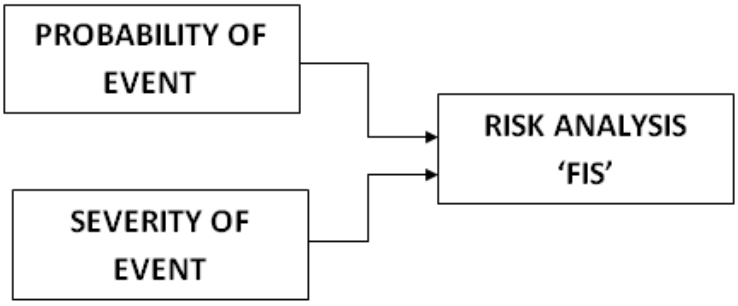

Figure 1.2 An Overview of FRAM

If we look at figure 1.2 then we can see that the inputs 'Probability' and 'Severity' are combined to build 'Risk analysis'.

3.2 Defining Universe of Discourse (UOD), Fuzzification of constraints and Membership function's (MF's)

In this study we have fuzzified each of the constraint i.e. risk, probability and severity with seven linguistic variables (fuzzy subsets: Extremely Low-EL, Very Low-VL, Low-L, Medium-M, High-H, Very High-VH, Extremely High) using triangular MF's [8]. 'Probability' has been given a UOD of [0 1] while 'Severity' and 'Risk' has been given a UOD of [0 100]. Examples of fuzzified constraints are shown from figure 1.3 to figure 1.5

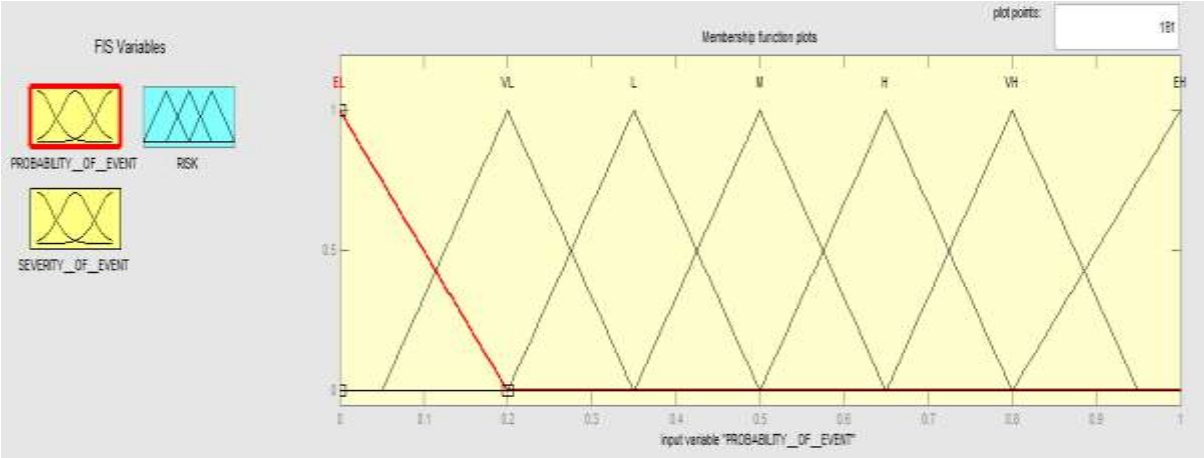

Figure 1.3 MF's for input – 'Probability' of occurrence of event

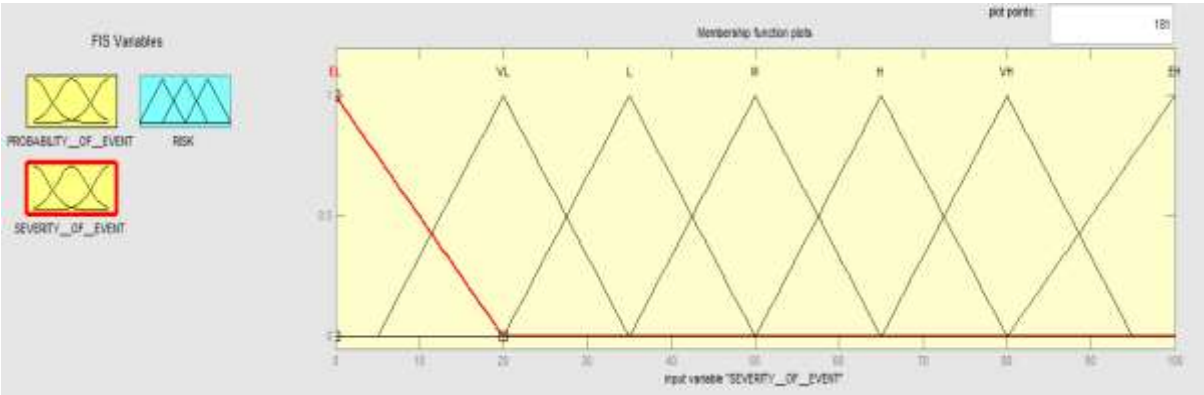

Figure 1.4 MF's for input – 'Severity' of event occurring

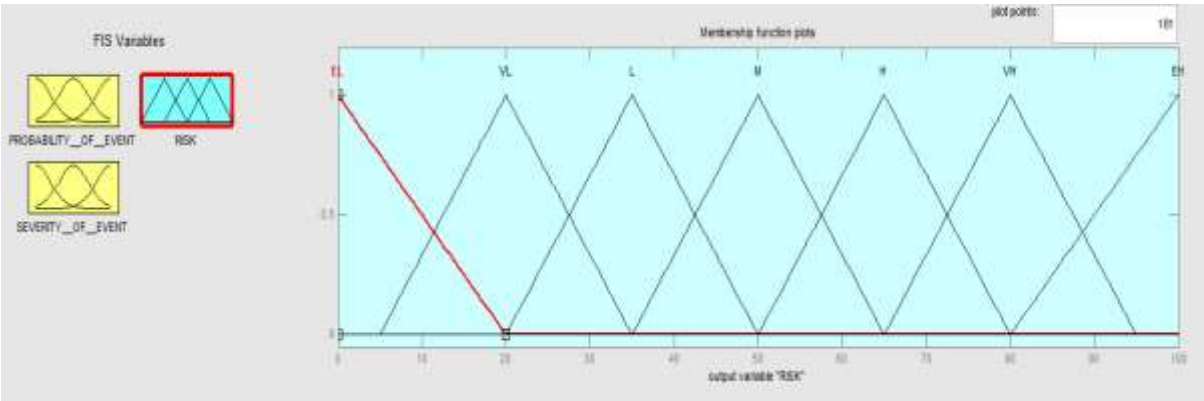

Figure 1.5 MF's for output – 'Risk'

3.3 Defining fuzzy control rules

Fuzzy control rules [8] for the fuzzy controller can be seen from table 1.0

PROBABILITY \ SEVERITY	EH	VH	H	M	L	VL	EL
EH	EH	EH	VH	VH	H	H	M
VH	EH	VH	VH	H	H	M	M
H	VH	VH	H	H	M	M	L
M	VH	H	H	M	M	L	VL
L	H	H	M	M	L	VL	VL
VL	H	M	M	L	VL	VL	EL
EL	M	M	L	VL	VL	EL	EL

Table 1.0 fuzzy control rules – 'FIS'

As can be seen from the table there are total forty nine rules e.g. if the rating for 'Probability' of occurrence of event is 'High' and rating for 'Severity' of event occurring is 'Extremely high' then the rating for 'Risk' is 'Very high'. The fuzzy rules are defined and based on personal experience of expert and varies from one expert to other.

A surface viewer for FIS is shown in figure 1.6 which demonstrates relationship among 'Probability', 'Severity' and 'Risk'. To achieve the surface we have used the fuzzy rule bases and the MF's of the FIS controller.

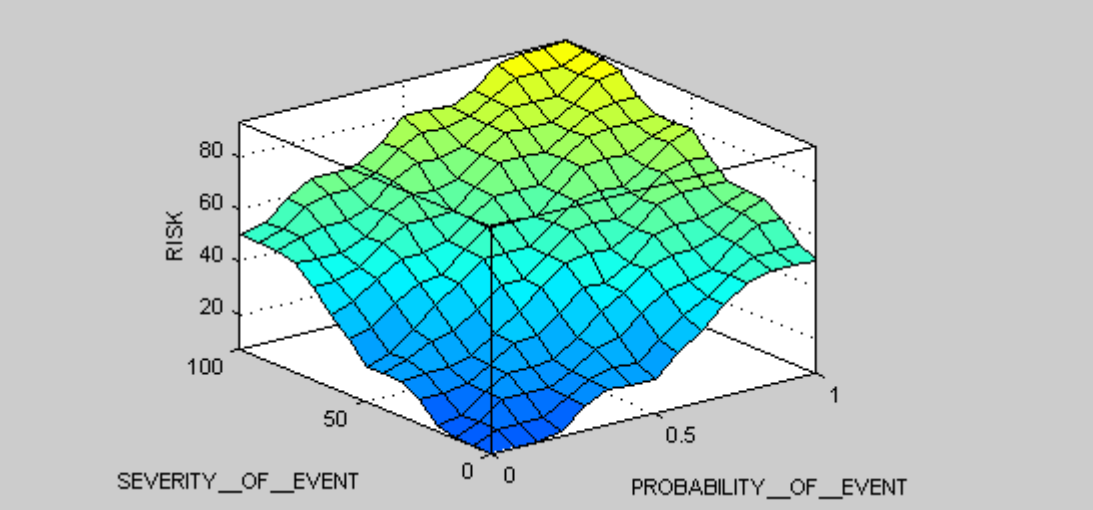

Figure 1.6 Surface viewer for 'FIS'

As can be seen from the figure 1.6 if one has numerical value of Probability and Severity in the scale of [0-1] and [0-100] respectively, we can obtain the amount of Risk associated in the scale of [0-100].

4.0 Modelling and Simulation

4.1 Designing of Simulink model

The proposed fuzzy reasoning model i.e. FRAM was developed in Matlab Simulink software using fuzzy logic toolbox [9] as shown in figure 1.7

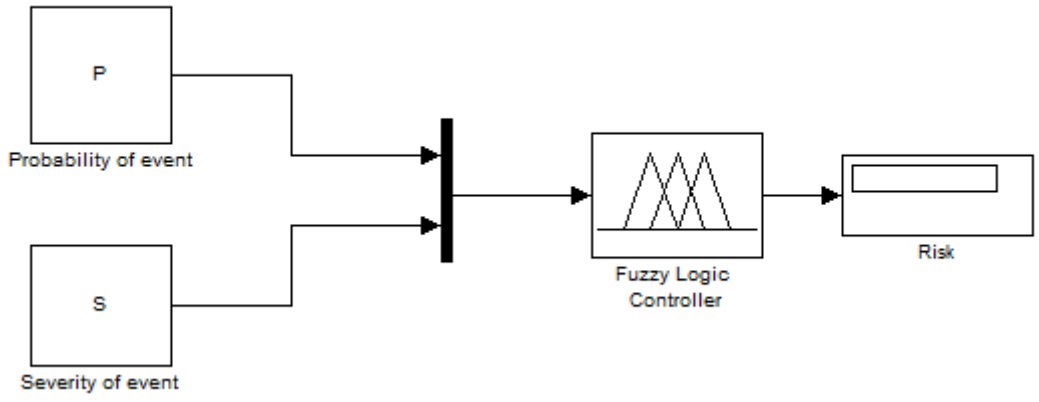

Figure 1.7 Simulink model- FRAM

4.2 Simulation results

Results of various simulations for different set of inputs i.e. Probability and Severity are shown below:

Set 1:
P = 0.5; S = 75
The simulation (t=2sec) results are shown in figure 1.8

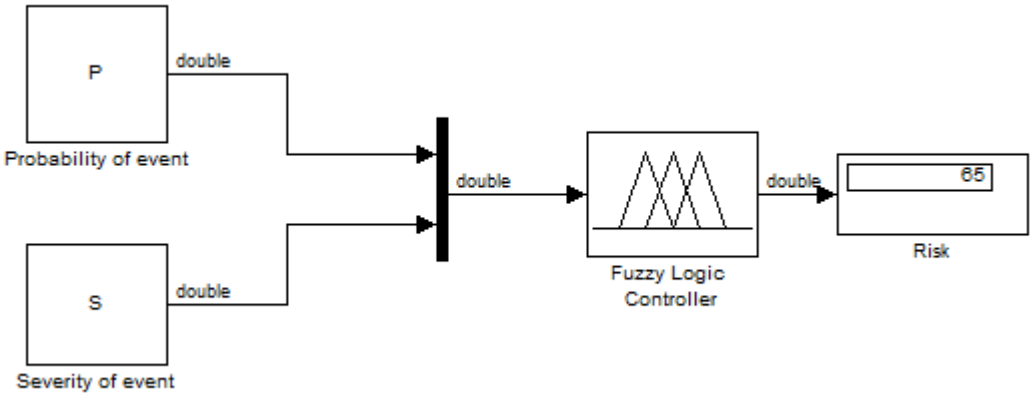

Figure 1.8 Simulation results

As can be seen from the figure 1.8 the assessed **Risk rating is 65.**

Set 2:
P = 0.75; S = 80
The simulation (t=2sec) results are shown in figure 1.9

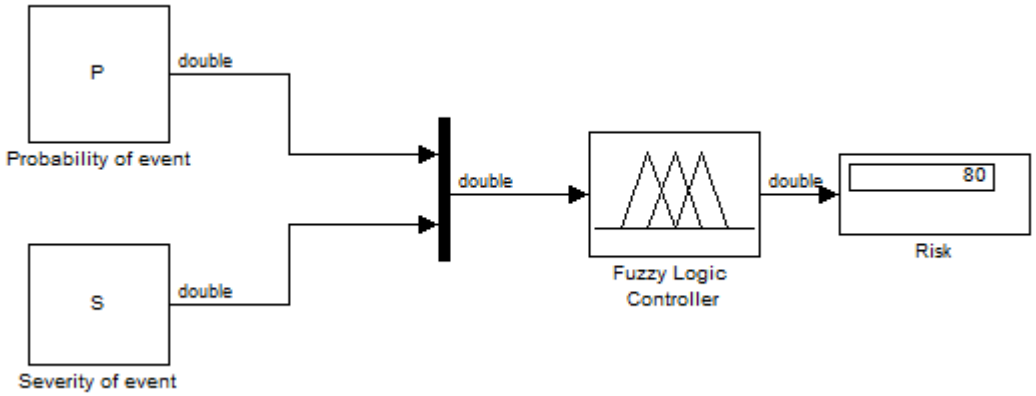

Figure 1.9 Simulation results

As can be seen from the figure 1.9 the assessed **Risk rating is 80.**

Set 3:
P =0.9; S = 40
The simulation (t=2sec) results are shown in figure 2.0

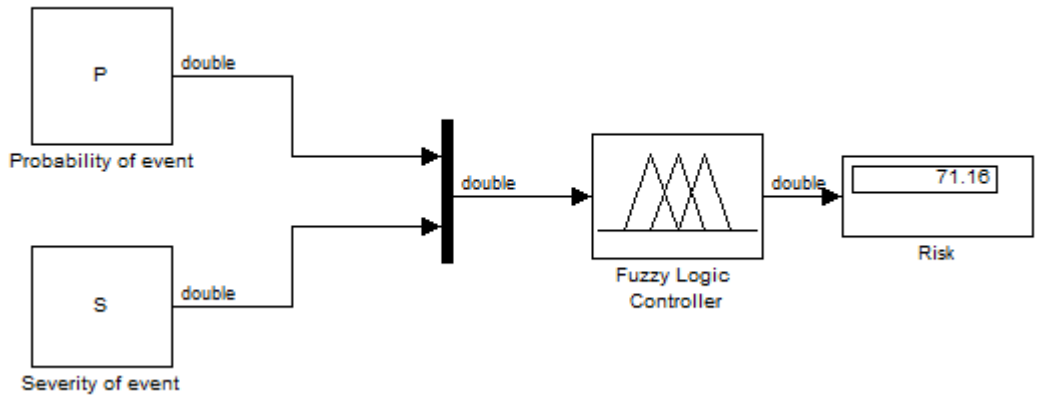

Figure 2.0 Simulation results

As can be seen from the figure 2.0 the assessed **Risk rating is 71.16**

5.0 Conclusion and Future outlook

A new approach for assessing risk in an organization using fuzzy logic reasoning has been proposed. Matlab Simulink models i.e. FRAM has been developed and results are shown. The proposed framework develops a model that optimises the risk constraints. The developed fuzzy risk assessment model (FRAM) provides a new methodology for risk assessment (RA) by capturing expert knowledge and allowing description of the expertise in more intuitive manner.

As an extension for future work one can also consider other constraints which effects RA, we can also apply fuzzy ordinal approach in RA if the number of constraints are more, we can also effectively apply fuzzy logic reasoning in other modern techno-management decision making problems.

6.0 References

[1] Ms Manisha.Ingle, Dr.Mohommad Atique, Prof. S. O. Dahad, "*Risk analysis using fuzzy logic*", International Journal of Advanced Engineering Technology, E-ISSN 0976-3945, Vol.II/ Issue III/July-September, 2011/96-99.

[2] J.K. Lein, Environ. Prof. 14 (1992) 257.

[3] Douglas, H. "*The Failure of Risk Management: Why It's Broken and How to Fix It"*. John Wiley & Sons. p. 46 (2009).

[4] A. Finizio, S. Villa, Environ. Impact Assessment Rev. 22 (3) (2002) 235.

[5] R.M. Darbra, E. Eljarrat, D. Barcel, "How to measure uncertainties in environmental risk assessment", Trends in Analytical Chemistry, Vol. 27, No. 4, 2008

[6] Marta Takacs, "*Multilevel Fuzzy Approach to the Risk and Disaster Management*", Acta Polytechnica Hungarica, Vol. 7, No. 4, 2010.

[7] Laszlo Pokoradi, "*Fuzzy logic-based risk assessment*", AARMS, Volume1, Issue 1 (2002) 63–73

[8] Adnan Shaout and Jaldip Trivedi, "*Performance Appraisal System Using a Multistage Fuzzy Architecture*", International Journal of Computer and Information Technology (ISSN: 2279 – 0764) Volume 02– Issue 03, May 2013.

[9] Fuzzy Logic Toolbox: User's Guide MathWorks,www.mathworks.com/help/pdf_doc/fuzzy/fuzzy.pdf

[10] D. Vose, Quantitative Risk Analysis – A Guide to Monte Carlo Simulation Modeling, Wiley, Chichester, West Sussex, UK, 1996.

[11] Kamil Boc, Juraj Vaculik, Dagmar Vidrikova, *"Fuzzy approach to risk analysis and its advantages against the qualitative approach*", Proceedings of the 12th International Conference "Reliability and Statistics in Transportation and Communication" (RelStat'12), *17–20 October 2012, Riga, Latvia, p. 234–239. ISBN 978-9984-818-49-8*

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