TQM as Nonprobabilistic Risk System

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TQM, mint nemvalószínűségi kockázati rendszer

Bevezetés

Aghaie (Aghaie, 2004) megszerkesztett egy „Az ISO 9001: 2000 bevezetésének sikertelensége" csúcseseményű hibafát 51 főeseménnyel és 78 - 51 = 27 közbenső eseménnyel. Azt feltételezte, hogy minden főesemény független és azonos valószínűségű (0,15). A hibafának öt ága van és ezek relatív valószínűségi súlyozásainak számítása manuálisan történt.
A jelen munkában a fenti eredményeket kibővítjük, és bemutatjuk, hogy ki lehet fejleszteni konzisztens kockázatelméletet bármely valószínűségi koncepció alkalmazása nélkül.
Aghaie említéseket tett elvágó halmazokról, de ezek közül egyet sem mutatott be. Egyáltalán nem foglalkozott a járathalmazokkal sem, annak ellenére, hogy azok döntő szerepet játszanak a rendszerhibák megelőzésében. Mi számba vesszük ennek a hibafának mind a járathalmazait, mind pedig az elvágó halmazait.
Aghaie a hibafáknak meglehetősen elavult ábrázolását alkalmazza (amelyet az informatikából kölcsönzött). Megmutatjuk, hogy hogyan kell alkalmazni ma a számítógépeket ahhoz, hogy rugalmasabb technikákat kínáljunk a hibafák kezelésére.

Introduction

Aghaie (Aghaie, 2004) has constructed a fault tree of top-event „Failed ISO 9001: 2000 in implementation", with 51 basic events and 78 – 51 = 27 intermediate events. He supposed that all the basic events are independent and have equval probability (0.15). The fault tree had five branches and their relative probabilistic weights were manually calculated.
In the present work we expand from the above results and demonstrate that a consistent theory of risk can be developed without any use of probability concept.
Aghaie made mentions about cutsets, but did not present any of them. Also, has not dealt with pathsets at all although they play crucial roles in preventing system failures. We enumerate both patsets and cutsets of his fault tree.
Aghaie uses a quite obsolete representation of fault trees (borrowed from electronic engineering). We show how to apply today computers to provide more elastic techniques for handling fault trees.

1. Why gates, not explorer?

Using Microsoft Windows® Office Word, outlook view one can find a quite straightforward and convenient way to represent fault tree. See Figure 1. -3. „Zooming" is most easy as opposed to the usual and standard gate diagrams. In that figures „&" and „V" corresponds to the logic operation *conjunction* (AND-connection) and *disjunction* (OR-connection) respectively. Basic event are written in small letters. Each event has a *registration number* indicating the logical hierarchy between the event in question.

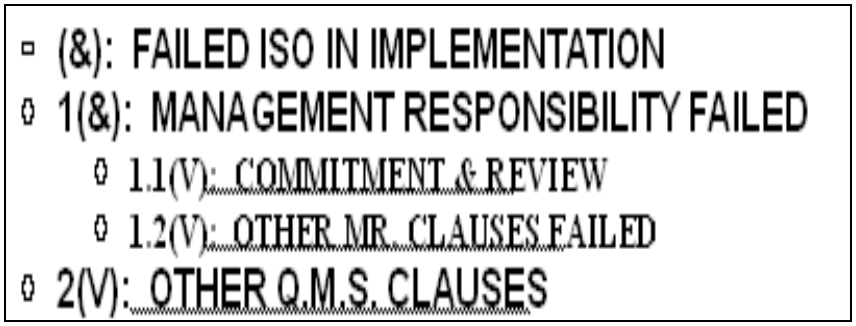


Figure 1.
Aghaie's Fault tree in Microsoft Windows® Office Word, Outlook View in collapsed form.

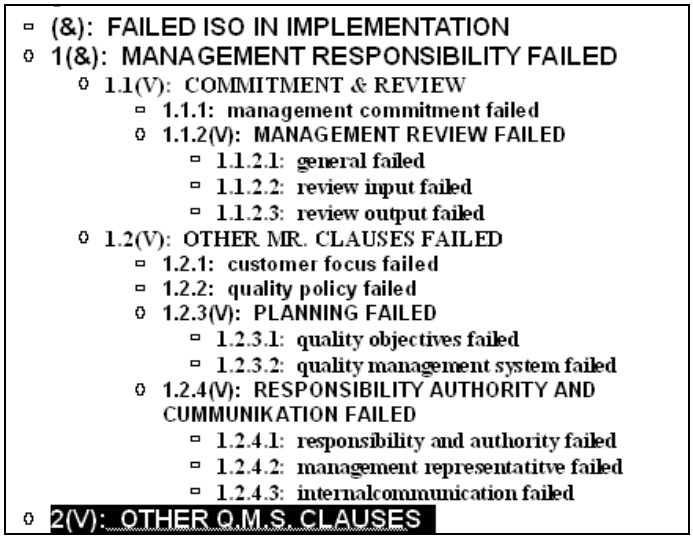


Figure 2.
Aghaie's Fault tree in Microsoft Windows® Office Word, Outlook View in expanded form, first degree.

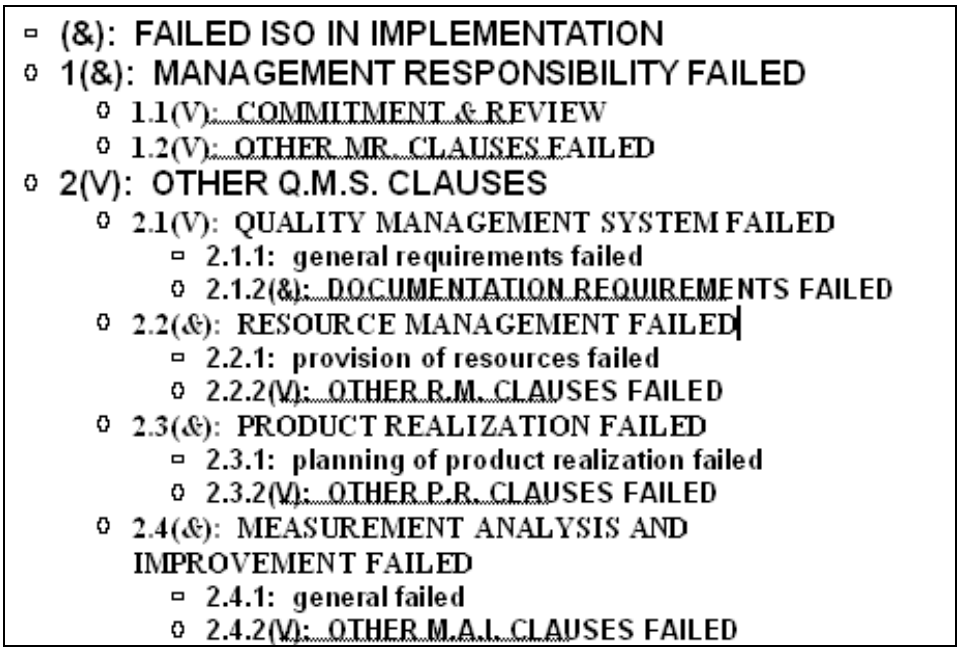


Figure 3.
Aghaie's Fault tree in Microsoft Windows® Office Word, Outlook View in more expanded form as in Figure 2.

2. Fault tree as Boolean function and/or Boolean equation system

As wellknown, a Fault tree is mathematically equivalent to a Boolean function of *m* variables where *m* is the number of *basic events*. Also, it is equivalent to a Boolean equation System of *n* members. In our case the number of equations, n = 27, m = 51 (basic events). If the variables are denoted by E1, E2,…En, n = 79, then the system is as follows:

E1 = E2 x E3
E2 = E8 x E9
E3 = E4 + E5 + E6 + E7
E4 = E24 + E25
E5 = E31 x E32
E6 = E51 x E52
E7 = E12 x E39
E8 = E10 + E11
E9 = E15 + E16 + E17 + E18
E11 = E12 + E13 + E14
E17 = E19 + E20
E18 = E21 + E22 + E23
E25 = E12 x E27
E27 = E28 + E29 + E30
E32 = E33 + E34 + E35
E33 = E12 x E37
E39 = E40 + E41 + E42 + E43
E40 = E44 + E45 + E46 + E47
E43 = E48 + E49 + E50

E52 = E53 + E54 + E55 + E56 + E57
E53 = E58 + E59
E54 = E66 x E67
E55 = E62 + E63
E56 = E75 + E76 + E77 + E78 + E79
E58 = E60 x E61
E63 = E64 x E65
E66 = E68 + E69 + E70 + E71
E67 = E72 + E73 + E74

If the basic events are denoted by p1, p2,…, p51, then

p1 = E10	p11 = E23	p21 = E37	p31 = E50	p41 = E69
p2 = E12	p12 = E24	p22 = E38	p32 = E51	p42 = E70
p3 = E13	p13 = E26	p23 = E41	p33 = E57	p43 = E71
p4 = E14	p14 = E28	p24 = E42	p34 = E59	p44 = E72
p5 = E15	p15 = E29	p25 = E44	p35 = E60	p45 = E73
p6 = E16	p16 = E30	p26 = E45	p36 = E61	p46 = E74
p7 = E19	p17 = E31	p27 = E46	p37 = E62	p47 = E75
p8 = E20	p18 = E34	p28 = E47	p38 = E64	p48 = E76
p9 = E21	p19 = E35	p29 = E48	p39 = E65	p49 = E77
p10 = E22	p20 = E36	p30 = E49	p40 = E68	p50 = E78
p51 = E79				

The meaning of the basic events can be seen in the Table 1 below:

Table 1:
The meaning of the events. (Basic events with small letters).

E1	FAILED ISO IN IMPLEMENTATION
E2	MANAGEMENT RESPONSIBILITY FAILED
E3	OTHER Q.M.S. CLAUSES
E4	QUALITY MANAGEMENT SYSTEM FAILED
E5	RESOURCE MANAGEMENT FAILED
E6	PRODUCT REALIZATION FAILED
E7	MEASUREMENT ANALYSIS AND IMPROVEMENT FAILED
E8	COMMITMENT & REVIEW
E9	OTHER MR. CLAUSES FAILED
E10	management commitment failed
E11	MANAGEMENT REVIEW FAILED
E12	general failed
E13	review input failed
E14	review output failed
E15	customer focus failed
E16	quality policy failed
E17	PLANNING FAILED
E18	RESPONSIBILITY AUTHORITY AND CUMMUNIKATION FAILED
E19	quality objectives failed
E20	quality management system failed
E21	responsibility and authority failed
E22	management representative failed
E23	Internal communication failed
E24	general requirements failed
E25	DOCUMENTATION REQUIREMENTS FAILED
E26	general failed
E27	DOCUMENTATION FAILED
E28	quality manual failed
E29	control of documents failed
E30	control of records failed
E31	provision of resources failed
E32	OTHER R.M. CLAUSES FAILED
E33	HUMAN RESOURCES FAILED
E34	infrastucture failed
E35	work environment failed
E36	general failed
E37	competence awareness and training failed
E38	general failed
E39	OTHER M.A.I. CLAUSES FAILED
E40	MONITORING AND MEASUREMENT FAILED
E41	control of nonconforming product failed
E42	analysis of data failed
E43	IMPROVEMENT FAILED
E44	customer satisfaction failed
E45	internal audit failed
E46	monitoring and measurement of processes failed

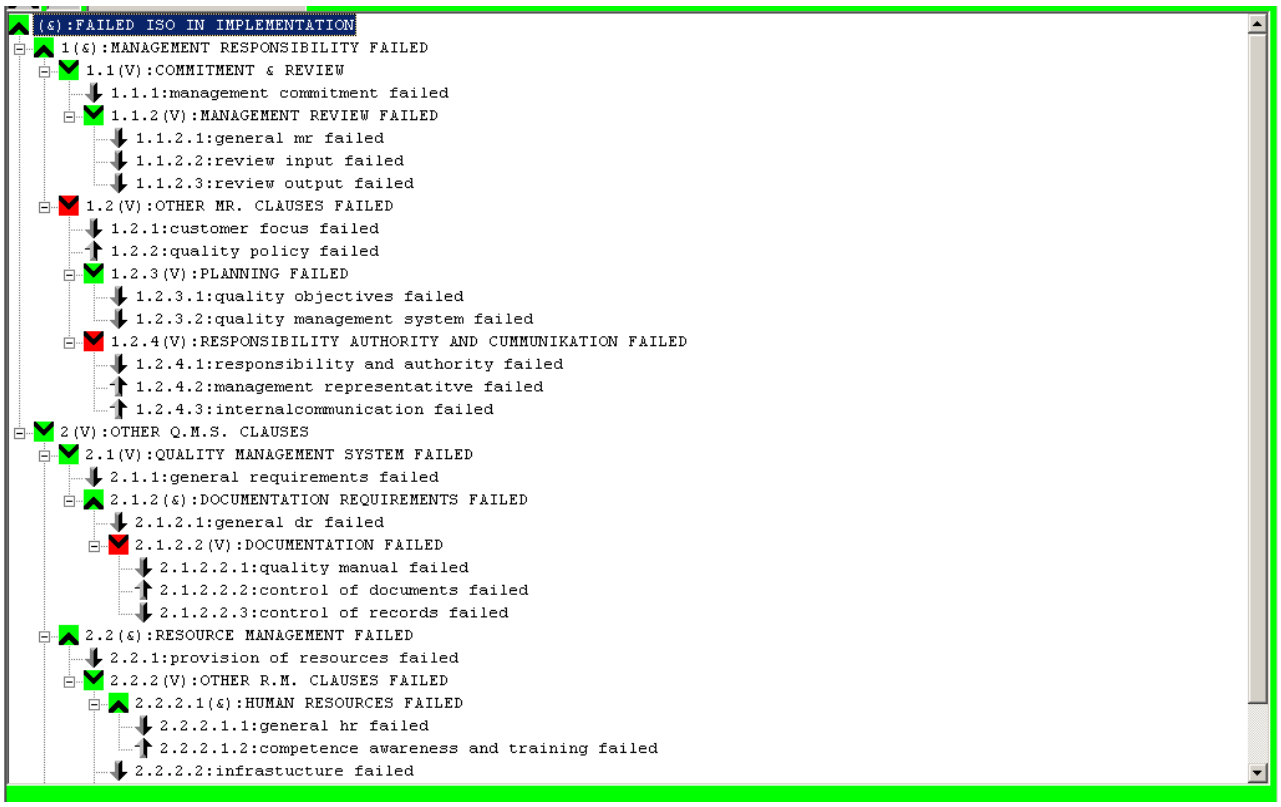
E47	monitoring and measurement of product failed
E48	continual improvement failed
E49	corrective action failed
E50	preventive action failed
E51	planning of product realization failed
E52	OTHER P.R. CLAUSES FAILED
E53	CUSTOMER RELATED PROCESSES FAILED
E54	DESIGN AND DEVELOPMENT FAILED
E55	PURCHASING FAILED
E56	production and service provision failed
E57	control of monitoring and measuring devices failed
E58	PRODUCT REQUIREMENTS FAILD
E59	customer communication failed
E60	determination requirements relating to the product faild
E61	review of requirements relating to the product failed
E62	purchasing process failed
E63	PURCHASED PRODUCT FAILED
E64	purchasing information failed
E65	verification of purchased product failed
E66	D.D. PROCESS FAILED
E67	D.D. REVIEW FAILED
E68	d.d. planning failed
E69	d.d. inputs failed
E70	d.d. outputs failed
E71	control d.d. changes failed
E72	d.d. review failed
E73	d.d. verification failed
E74	d.d. validation failed
E75	control of production and service provision failed
E76	validation of processes for production and service provision failed
E77	identification and traceability failed
E78	customer property failed
E79	preservation of product failed

3.The states of a risk system

If an event E is the case (ie. it occurs) then it is said that (the state of) E is *active*, otherwise *passive*.
If the top event, ie E1, is the case, then we say that the System is in the *active state*, or the System is *active*. *Mutatis mutandis* for the *passive* system state.
By definition, the *state of the risk system* is the set of all the *active* basic events.
Evidently,
the state of the system is active if and only if the Boolean logic value of E1 = True,
the state of the system is passive if and only if the Boolean logic value of E1 = False.

The following „**SES”**-statements (State Evaluation Statements) are also evident:
A conjunction is true if and only if all of its factors (operands) are true,
A disjunction is false if and only if all of its members (operands) are false.
Equivalently, (by dual reasoning)
A conjunction is false if and only any of its factors (operands) are false,
A disjunction is true if and only any of its members (operands) are true.

The state of the risk system can conveniently be represented by a colored MSFlexGrid of Microsoft Visual Basic® (version VB6, attached to Microsoft Office) like on the next picture. Here the states of the basic events are represented by arrows (up for active, down for passive). Composite events are colored according to their state (red for active, green for passive). See Picture 1



Picture 1
A Colored fault tree showing a current system state. (Excerpt)
One can check the SES-statements's validity.

Any state of the risk system can also be represented either the *state page* or by the *state table*. Formally both are tables (grids), providing different conveniences for different occasions. For the state page corresponding to that of the above Picture1 is on Figure 4:

#P	Activity	Registration Number	Event name
01		1.1.1	management commitment failed
02		1.1.2.1	general mr failed
03		1.1.2.2	review input failed
04		1.1.2.3	review output failed
05		1.2.1	customer focus failed
06	X	1.2.2	quality policy failed
07		1.2.3.1	quality objectives failed
08		1.2.3.2	quality management system failed
09		1.2.4.1	responsibility and authority failed
10	X	1.2.4.2	management representatitve failed
11	X	1.2.4.3	internalcommunication failed
12		2.1.1	general requirements failed
13		2.1.2.1	general dr failed
14		2.1.2.2.1	quality manual failed
15	X	2.1.2.2.2	control of documents failed
16		2.1.2.2.3	control of records failed
17		2.2.1	provision of resources failed
18		2.2.2.2	infrastucture failed
19		2.2.2.3	work environment failed
20		2.2.2.1.1	general hr failed
21		2.2.2.1.2	competence awareness and training failed
22		2.4.1	general failed
23		2.4.2.2	control of nonconforming product failed
24	X	2.4.2.3	analysis of data failed
25	X	2.4.2.1.1	customer satisfaction failed
26		2.4.2.1.2	internal audit failed
27		2.4.2.1.3	monitoring and measurement of processes failed
28		2.4.2.1.4	monitoring and measurement of product failed
29		2.4.2.4.1	continual improvement failed
30		2.4.2.4.2	corrective action failed
31	X	2.4.2.4.3	preventive action failed
32		2.3.1	planning of product realization failed
33		2.3.2.5	control of monitoring and measuring devices failed
34	X	2.3.2.1.2	customer communication failed
35		2.3.2.1.1.1	determination requirements relating to the product faild
36		2.3.2.1.1.2	review of requirements relating to the product failed
37		2.3.2.3.1	purchasing process failed
38		2.3.2.3.2.1	purchasing information failed
39		2.3.2.3.2.2	verification of purchased product failed
40		2.3.2.2.1.1	d.d. planning failed
41		2.3.2.2.1.2	d.d. inputs failed
42		2.3.2.2.1.3	d.d. outputs failed
43		2.3.2.2.1.4	control d.d. changes failed
44		2.3.2.2.2.1	d.d. review failed
45		2.3.2.2.2.2	d.d. verification failed
46	X	2.3.2.2.2.3	d.d. validation failed

#P	Activity	Registration Number	Event name
47		2.3.2.4.1	control of production and service provision failed
48		2.3.2.4.2	validation of processes for production and service provision failed
49	X	2.3.2.4.3	identification and traceability failed
50		2.3.2.4.4	customer property failed
51		2.3.2.4.5	preservation of product failed

Figure 4:
The state page corresponding to Picture 1

For the *state table* corresponding to that of the above Picture1 is on Figure 5:

	00	01	02	03	04	05	06	07	08	09
00	0	p = 01, 1.1.1: management commitment failed	p = 02, 1.1.2.1: general mr failed	p = 03, 1.1.2.2: review input failed	p = 04, 1.1.2.3: review output failed	p = 05, 1.2.1: customer focus failed	p = 06, 1.2.2: quality policy failed	p = 07, 1.2.3.1: quality objectives failed	p = 08, 1.2.3.2: quality management system failed	p = 09, 1.2.4.1: responsibility and authority failed
10	p = 10, 1.2.4.2: management representatitve failed	p = 11, 1.2.4.3: ternalcommunicatic failed	p = 12, 2.1.1: general requirements failed	p = 13, 2.1.2.1: general dr failed	p = 14, 2.1.2.2.1: quality manual failed	p = 15, 2.1.2.2.2: control of documents failed	p = 16, 2.1.2.2.3: control of records failed	p = 17, 2.2.1: provision of resources failed	p = 18, 2.2.2.2: infrastucture failed	p = 19, 2.2.2.3: work environment failed
20	p = 20, 2.2.2.1.1: general hr failed	p = 21, 2.2.2.1.2: competence awareness and training failed	p = 22, 2.4.1: general failed	p = 23, 2.4.2.2: control of nonconforming product failed	p = 24, 2.4.2.3: analysis of data failed	p = 25, 2.4.2.1.1: customer satisfaction failed	p = 26, 2.4.2.1.2: internal audit failed	p = 27, 2.4.2.1.3: monitoring and measurement of processes failed	p = 28, 2.4.2.1.4: monitoring and measurement of product failed	p = 29, 2.4.2.4.1: continual improvement failed
30	p = 30, 2.4.2.4.2: corrective action failed	p = 31, 2.4.2.4.3: preventive action failed	p = 32, 2.3.1: planning of product realization failed	p = 33, 2.3.2.5: control of monitoring and measuring devices failed	p = 34, 2.3.2.1.2: customer communication failed	p = 35, 2.3.2.1.1.1: determination requirements relating to the product faild	p = 36, 2.3.2.1.1.2: review of requirements relating to the product failed	p = 37, 2.3.2.3.1: purchasing process failed	p = 38, 2.3.2.3.2.1: purchasing information failed	p = 39, 2.3.2.3.2.2: verification of purchased product failed
40	p = 40, 2.3.2.2.1.1: d.d. planning failed	p = 41, 2.3.2.2.1.2: d.d. inputs failed	p = 42, 2.3.2.2.1.3: d.d. outputs failed	p = 43, 2.3.2.2.1.4: control d.d. changes failed	p = 44, 2.3.2.2.2.1: d.d. review failed	p = 45, 2.3.2.2.2.2: d.d. verification failed	p = 46, 2.3.2.2.2.3: d.d. validation failed	p = 47, 2.3.2.4.1: control of production and service provision failed	p = 48, 2.3.2.4.2: validation of processes for production and service provision failed	p = 49, 2.3.2.4.3: identification and traceability failed
50	p = 50, 2.3.2.4.4: customer property failed	p = 51, 2.3.2.4.5: preservation of product failed								

Figure 5:
The state table corresponding to Picture 1

4. Cost, instead of probability

To assign probability to a singular (individual) event is meaningless.
On the contrary, every insurance company supposes that to (practically) all events there can be assigned a well-defined amount of money. As a generalization we suppose, that to every basic event of a risk system a well-defined cost of prevention and renovation cost can be assigned.. Also, we suppose, (in the spirit of Benjamin Franklin's „Time is money"), that to every basic event of a risk system a well defined amount of prevention and renovation time can be assigned. By this stipulation the „best" base events can be determined in both senses vis. the *cheapest* and the *shortest* ones respectively for *arresting* and *preventing* as well.

5. Probability for voting

A decision process can be modeled as a stochastic process. Also, a positive Boolean function (not containing negation) can be represented by a switching circuit, which, again, serves as a *voting* model. (Moore-Shannon, 1952). This model is characterized by the Quorum function (in a broader sense than that of the original one). The domain of definition of the Quorum function F(P) (belonging to the top event E1(p1,p2,…,pN) of the risk system in question) is the interval [0, 1]. Here P is the probability of the vote for the top event (E1) being the case with probability F (on Figure 2)
Figure 2 below shows the Quorum function for Aghaie's fault tree. According to Moore-Shannon's the theory of Quorum, the limit of consensus (or the decidability) is 16,16%.

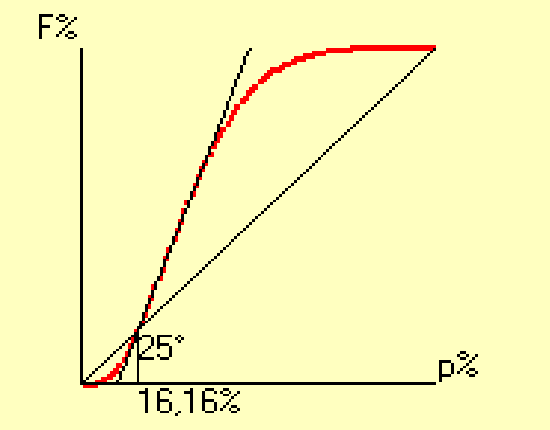


Figure 2
The Quorum funtion of the Aghaie's fault tree

References

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