APPLYING PERT AND CRITICAL PATH METHOD IN HUMAN RESOURCE TRAINING

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Abstract: *The subject of the article is referring to the modelling and simulating of the formation of human resources by applying the PERT/CPM (Program Evaluation and Review Technique/Critical Path Method) and the taking into consideration of some risks associated to this activity. The aim of the article is to offer practical support to the management of organizations in order to make a formation program of human resources, which implies activities of precedence and interrelated, critical paths, the distribution of time resources and necessary costs for the fulfilment of the organizational objectives.*
Keywords: PERT chart, critical path, risk, human resources, modelling, simulation.
JEL Classification: C_{54}, C_{63}.

1. Introduction

The abbreviation PERT/CPM is derived from the Program Evaluation and Review Technique/Critical Path Method, and the combination of the two methods enables planning of interrelated activities in order to estimate time and cost required to complete their inheritance (Ionescu Gh. Gh., Cazan, E., Negruşa A. L., 1999, p. 144), (Rusu, E., 2001, p. 45).

PERT chart was used and developed for the first time in 1950 by U.S. Navy to design a missile (planning of Polaris military project) and the critical path method was created by Du Pont also in 1950 for planning chemistry projects. Subsequently, these methods have been used in various fields and that is why we appreciate that they can be applied to human resource training.

2. Applications

In a case study on human resource training, the procedure is done in four stages, assuming that this can be made within thirty days by a trainer

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within the organization, paid 30 euro/day. The organization management found that training tasks are not interrelated and therefore wish to consider the impact on cost and time that it may have hiring an expert (external trainer) that can take the tasks no. 2 and 3, and task 1 and 4 to remain for the initial trainer. Due to the expert trainer professional skills he asks to be paid 35 euros per day.

The four tasks of the trainer will be:

Task 1

2 days- establishing the training needs and objectives

Task 2

6 days – creating the training plan

Task 3

 20 days- training

Task 4

2 days – training evaluation.

Assuming that all tasks are executed within 30 days by the trainer chosen by the organization management, the project cost will be 900 euros.

The cost of the training can be achieved both by normal numeracy and problem solved by introducing data WinQSB program that we will use our application, as follows:

Stage 1

From the keyboard the following are inserted in the module PERT/CPM of the software WinQSB: tasks performed, time and costs, if using internal trainers, resulting in the image below:

Activity Number	Activity Name	Immediate Predecessor (list number/name, separated by ',')	Normal Time	Normal Cost
1	Task 1		2	60
2	Task 2	1	6	180
3	Task 3	2	20	600
4	Task 4	3	2	60

Fig. 1 - Representing the activities to be performed,
the necessary time and its costs

Stage 2

By using the comand *Format → Swith to Graphic Model* we obtain the chart PERT, when the trainer of the organization is used, being represented in fig.2.
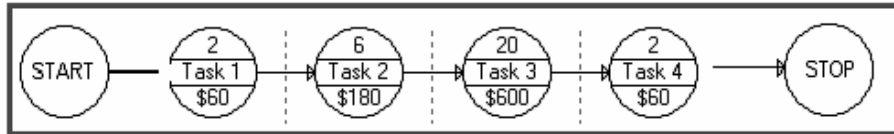

*Fig. 2 - Chart PERT representing the tasks between the
time and costs of the organization trainer*

So, using the PERT technique we obtain a network diagram view of the executed tasks, their precedence and critical path in human resource training with trainers within the organization. This chart helps us to establish a calendar of activities, the road map and their costs.

Stage 3

By ordering *Solve Critical Path* to obtain the critical path, its cost, time and total cost of the training activity and times of start and completion of each task in hand, as shown below.

03-13-2011 12:18:00	Activity Name	On Critical Path	Activity Time	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Slack (LS-ES)
1	Task1	no	0	0	0	0	0	0
2	Task2	no	2	0	2	0	2	0
3	Task3	no	6	2	8	2	8	0
4	Task4	no	2	8	10	8	10	0
	Project	Completion	Time	=	10	days		
	Total	Cost of	Project	=	$900	(Cost on	CP =	0)
	Number of	Critical	Path(s)	=	0			

*Fig. 3 - The chart PERT representing the critical path,
its cost and the total time of training*

Let us suppose that the organization trainer, after completing the task 1 (establishing the training needs and objects) is replaced by an external expert who takes the task 2 and 3.

To solve this problem we might take the steps used in the anterior situation, the chart and the next sketches:

Stage 1

From the keyboard the following are inserted in the module PERT/CPM of the software WinQSB: tasks performed, time and costs, if using internal trainers, resulting in the image below:

Fig. 4 - Representing the activities to be performed,
the necessary time and its costs

Stage 2

By using the comand *Format → Swith to Graphic Model* we obtain the chart PERT, when the expert is used, represented in fig. 5.
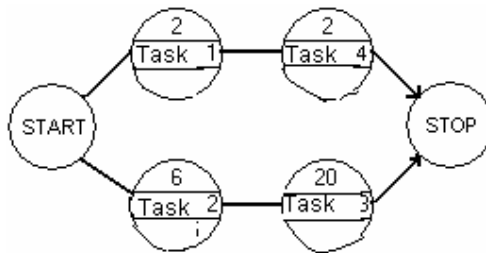

Fig.5. Chart PERT reprezenting the crtical path,
marked with blue, training time and costs

Stage 3

By ordering *Solve Critical Path* we obtain the critical path, its cost, time and total cost of the training activity, marked in blue and times of start and completion of each task, as shown below.

03-13-2011 12:28:06	Activity Name	On Critical Path	Activity Time	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Slack (LS-ES)
1	Task1	no	2	0	2	22	24	22
2	Task2	Yes	6	0	6	0	6	0
3	Task3	Yes	20	6	26	6	26	0
4	Task4	no	2	2	4	24	26	22
	Project	Completion	Time	=	26	days		
	Total	Cost of	Project	=	$1.035	(Cost on	CP =	$915)
	Number of	Critical	Path(s)	=	1			

Fig. 6 - Chart PERT representing the critical path,
training cost and time

3. Conclusions

Finally, after the analysis of the new chart, organization management notes: duration of activity decreased from 30 days to 26 days, the duration of the longest sequence of operations, sequence called critical path. In the diagram, the critical path is marked with a blue arrow and refers to the branch that determines the length of time required to complete the training. This is always marked by the longest period.

The organization trainer is working four days with a tarif of 30 euros per day, at a total of 120 euro. The expert is working 26 days with 35 euros per day, thus receiving a total of 910 euros, which would increase the cost of 900 euros to 1035 euros, unfavorable situation for the project. The organization management must choose and decide between money and time, to accept a shorter time with four days to complete the work, with an increase in costs of 235 euros or to continue training with the organization trainer.

For our application, we appreciate that time is more valuable than the extra cost, because it will lead, ultimately, to higher earnings, both time and money. .

Often, in initial and continuous training of human resources, organizations should initiate larger projects, involving many interrelated

activities, some of which are affected by events or risk factors that may affect the training objectives. In such cases, human resource training officers must be prepared to schedule all these activities and allocate the necessary resources, risk management, so the training project to be completed on time.

Risk modelling and simulation in training human resources by the method PERT / CPM and WinQSB software can be put in value also by taking into account the risk factors that can impact the cost and time in preparing, designing, implementing and evaluating a proper program of training human resources.

Of course, there are a variety of risk factors that may affect each stage of human resource training and specific activities that can be quantified in terms of running cost and schedule of activities (Andreica, M., Stoica, M., 1998, pp. 89-92), (Burloiu, P., 2010, pp. 44-53), (Nica, E., 2010, pp. 66-68).

Table 1

Project of human resouce training, containing
the succesive activities with their time and costs

Nr. crt.	Activity code	Description	Activities Directly precedent	duration (30 euro/day)
1	A	Identifying the training needs	-	3/90 euro
2	B	Establishing the the training participants	A	4/120 euro
3	C	Establishing the training objectives	A	4/120 euro
4	D	Planning the training tematical content	C	4/120 euro
5	E	Establishing the training teachers	A	1/30 euro
6	F	Training completing methods	C	5/150 euro
7	G	Program implementation	B,D	5/150 euro
8	H	Partial evaluation	G	1/30 euro
9	I	Logistics insurrance	F,G	2/60 euro
10	J	Apreciating and evaluation of the training results	H	1/30 euro

In this regard, we present **a new case study** in which the management of a company initially approved teaching of 100 new people hired for the profession of sellers over a period of 30 days and then, following events and factors risk, the company management had to fix other periods and costs for

the training itself. This is way, in Table1 is presented an example of human resource training activities, their durations and precedence relations training activities. Previously, these activities refer to the ones which must be completed before the work to do, so that it can begin. The time that it will consume each activity was estimated subjectively, so it can be made an appointment with the total time to complete the project. All these elements are analyzed and assembled in a soft model made automatically by the software WinQSB.

The organization's management estimates the duration of the course of 30 days in normal situations, of 10 days, 14 days respectively, as following of the occurence of some events and risk situations and requests the responsible ones with the training of the future sellers to establish the critical path, the cost and the length of the course, as follows:

a) established time of 30 days;

b) in 10 days, as following of the occurence of some events and risk situations: high request from the customers of the products offered for sale;

The organization's management asks that the people responsible with training the future sellers to know the critical path, time and cost of the training:

c) in terms of 30 days;

d) in 10 days, due to the appearance of some risk situations and events:

   - great solicitude, by the clients, of the products to sell;

   - market competition at the products to be sold;

   - apropriate terms of validity of the products.

e) in 14 days, therefore the probability of occurrence of risk factors in the training, implementation and evaluation of the course itself (eg the trainer health problems, failures in logistics management and technical equipment, etc.)

Solving the problem
a) in 30 days:

Stage 1
From the keyboard we put in the modul PERT/ CPM the soft WinQSB: the activities to be performed, their precedence, the 30 days time, and its costs, obtaining the image under:

*Fig. 7 - Representing the activities to be performed,
the necessary time and its costs*

Stage 2

By using the commands *Format → Swith to Graphic Model* we obtain the chart PERT, represented in fig. 8.
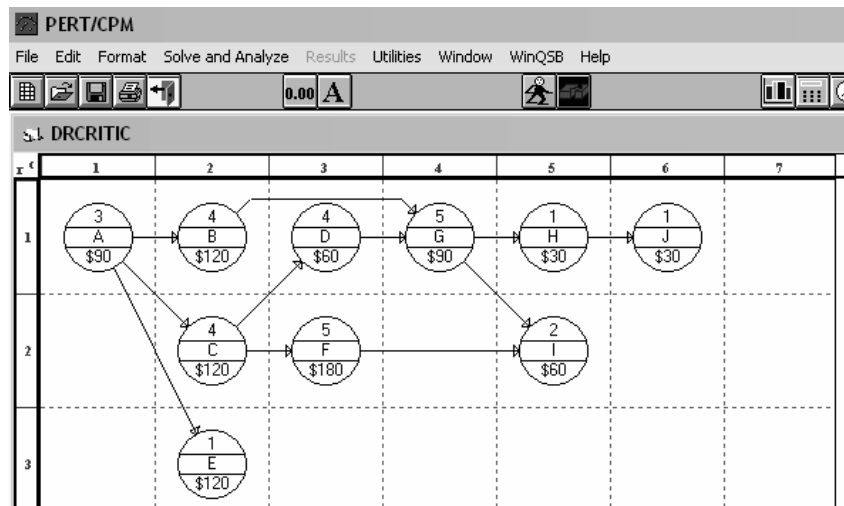

Fig. 8 - Chart PERT representing training time and costs

It is known that for the PERT method there are two solutions: the soft with the activities marked with arrows and the soft with the activities in knots. The charts shown by WinQSB are from the second type, withe the knots activities, as it is shown in fig. 8.

The circular representations containing the activities codified with A,B,C,D,E,F,G,H,I,J, in thebelow part of the knots, and above are being mentioned the costs. The activities sequence is induced by the arrows orientation from the chart PERT, shown by the soft WinQSB.

Stage 3

By choosing the command *Solve Critical Path* we obtain the critical path, its costs, time and total costs of training activities, as the starting and ending moments of each task, as the fig. below.

02-15-2011 21:07:48	Activity Name	On Critical Path	Activity Time	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Slack (LS-ES)
1	A	Yes	3	0	3	0	3	0
2	B	no	4	3	7	7	11	4
3	C	Yes	4	3	7	3	7	0
4	D	Yes	4	7	11	7	11	0
5	E	no	1	3	4	17	18	14
6	F	no	5	7	12	11	16	4
7	G	Yes	5	11	16	11	16	0
8	H	Yes	1	16	17	16	17	0
9	I	Yes	2	16	18	16	18	0
10	J	Yes	1	17	18	17	18	0
	Project	Completion	Time	=	18	ZILEs		
	Total	Cost of	Project	=	$900	[Cost on	CP =	$480]
	Number of	Critical	Path(s)	=	2			

*Fig. 9 - The chart PERT representing the critical path,
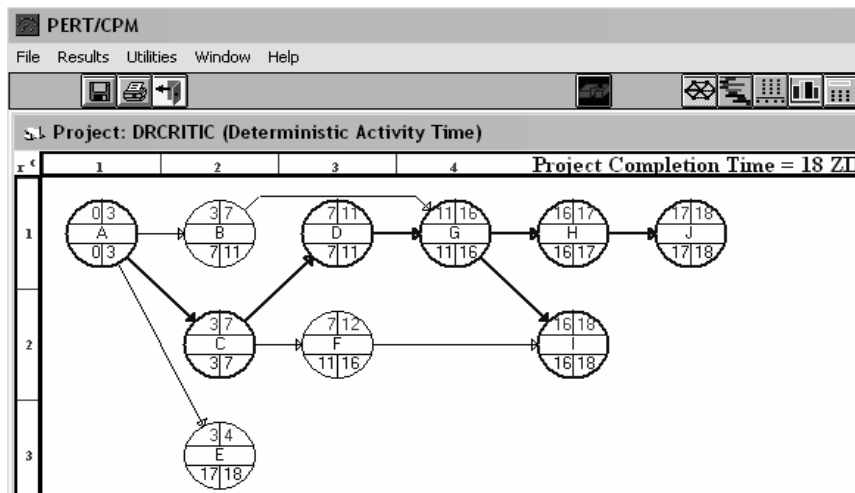training costs and time*

Fig. 10 - The crtical path marked with red

From the charts 9 and 10 result two critical roads, the first contain the activities A-C-D-G-H and J, and the second, contains the activities A-C-D-G-I, each with a total duration of 18 days, the activities being predicted in a limited time shown in the third column from fig.10. In the columns 4,5,6,7 and 8 are shown the starting and ending moments of each activity, as well as the differnces between the earliest ending moment and and the earliest starting moment of each activity. The cost of the critical path has been automatically calculated by the program, at 480 euro, and the total cost of the project at 900 euro.

Solving the problem
b) in 10 days:

Stage 4

By using the command *Solve Critical Path Using Crash Time* we obtain the critical path, its cost, the training time and total cost, as well as the starting and ending moments of each task (for problem b), as the fig. below.

02-15-2011 21:08:49	Activity Name	On Critical Path	Activity Time	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Slack (LS-ES)
1	A	Yes	1	0	1	0	1	0
2	B	no	1	1	2	2	3	1
3	C	Yes	1	1	2	1	2	0
4	D	Yes	1	2	3	2	3	0
5	E	no	1	1	2	5	6	4
6	F	no	1	2	3	4	5	2
7	G	Yes	1	3	4	3	4	0
8	H	Yes	1	4	5	4	5	0
9	I	no	1	4	5	5	6	1
10	J	Yes	1	5	6	5	6	0
	Project	Completion	Time	=	6	ZiLEs		
	Total	Cost of	Project	=	$300	[Cost on	CP =	$180]
	Number of	Critical	Path(s)	=	1			

Fig. 11 - Chart PERT representing the critical path, training time and cost (problem b case)
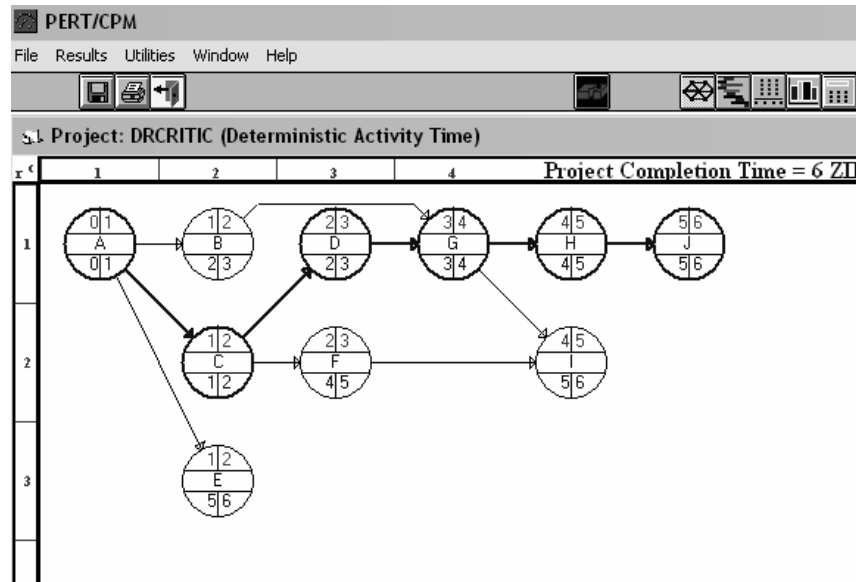
Fig. 12 - The critical path marked with red

From Figures 11, 12 results that the critical path contains A-C-D-G-H-J activities, with a total duration of six days, each activity being assigned a time limit set forth in the third column of fig. 11. In columns 4,5,6,7 and 8 are shown the times of onset and the completion of each activity, and differences between the earliest completion time and the earliest start time of each activity. Critical Path cost was calculated automatically by the program, the amount of 180 euros and the total project cost EUR 300.

Solving problem
c) in 14 days:

Stage 5
If we wish to finish the activities within 14 days, between the minimal value (6 days-critical path from problem "b") and maximum (18 days-critical path from problem "a"), we can use the option *Crashing Analysing*. In the window we write as followes:
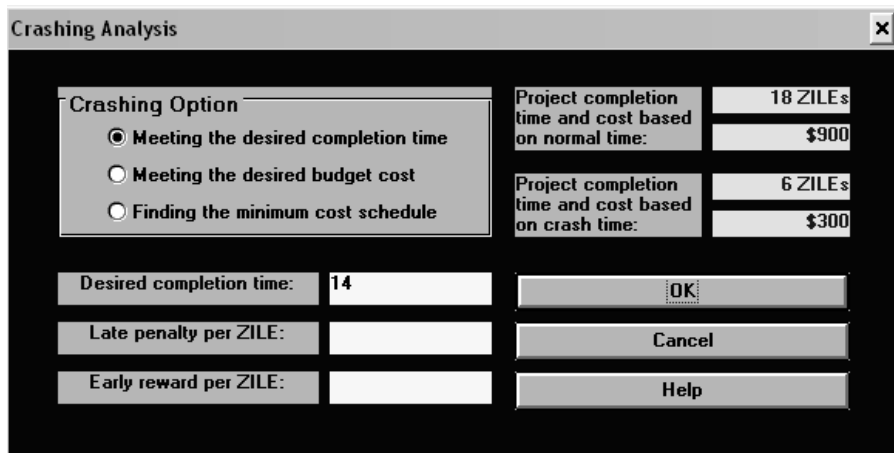
Fig. 13 - Introduction of time for problem c)

It will get a table setting out the costs and durations of activities for the entire sequence of activities to be completed within the period required by us, 14 days:

02-15-2011 21:13:56	Activity Name	Critical Path	Normal Time	Crash Time	Suggested Time	Additional Cost	Normal Cost	Suggested Cost
1	A	Yes	3	1	1	0	$90	$90
2	B	Yes	4	1	2	0	$120	$120
3	C	Yes	4	1	1	0	$120	$120
4	D	Yes	4	1	1	0	$60	$60
5	E	no	1	1	1	0	$120	$120
6	F	Yes	5	1	2	0	$180	$180
7	G	Yes	5	1	1	0	$90	$90
8	H	Yes	1	1	1	0	$30	$30
9	I	Yes	2	1	2	0	$60	$60
10	J	Yes	1	1	1	0	$30	$30
Overall	Project:				6	0	$900	$900

Fig. 14 - Chart PERT represented the critical path, training time and cost for problem c)
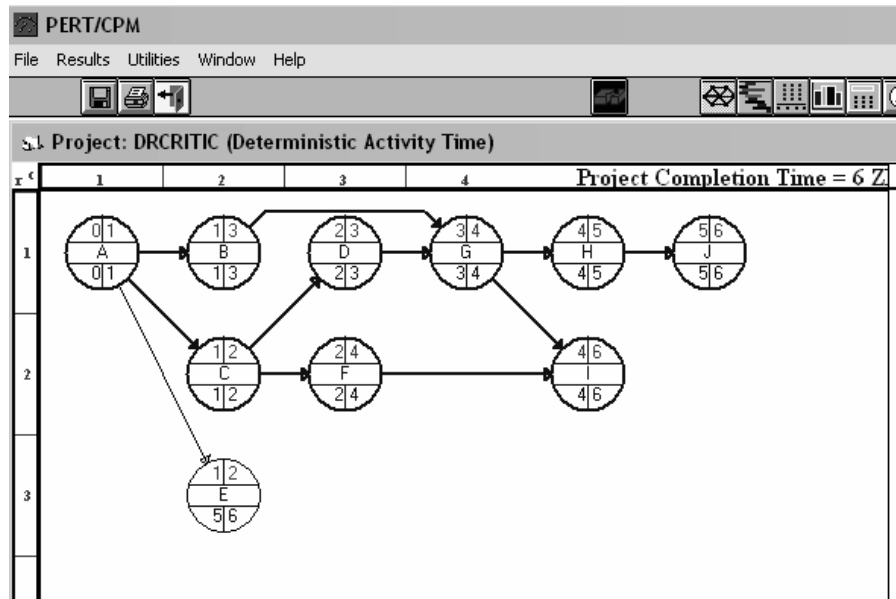
*Fig. 15 - The critical path
marked with red*

The figure above shows that the critical path includes activities A-B-C-D-F-G-H-I-J with a total duration of 13 days, each activity being assigned a time limit set forth in the third column of fig.14. In columns 4,5,6,7 and 8 are shown the times of onset and the completion of each activity, and differences between the earliest completion time and the earliest start time of each activity. Critical Path cost was calculated automatically by the program, the amount of 780 euros and the total project cost amounted to 900 euros.

The program displays a suggestion for solving the problem c), which can be solved in 14 days, dividing the soft period and costs associated activities. It is noted that for 14 days it still costs 900 euros.

A summary of the results in solving the three problems is shown in the table below; here we included for each problem: the critical path and its duration, cost of critical path and the cost of the project of human resource training.

Table 2

The results of the PERT analysis

	Problem a)/ 30 days	**Problem b)/ 10 days**	**Problem c)/ 14 days**
Critical path/ duration of critical path	A-C-D-G-H-J, A-C-D-G-I /18 days	A-C-D-G-H-J /6 days	A-B-C-D-F-G-H-I-J/13 days
The critical path cost	480 euro	180 euro	780 euro
The project cost	900 euro	300 euro	900 euro

4. Conclusions

By applying the PERT/CPM technique we highlighted a partical method of arranging and visualising by using the network diagram the precendence and interrelation of some specific activities to the formation of human resources, critical paths, the influence of some risk factors and we offered a practical support for taking the managerial decision on the distribution of time resources and costs necessary to the fulfilment of the objectives established by the organization's management.

So, after taking preliminary steps of PERT chart (identify activities, identifying precedents, estimated time, build the network) to solve every problem, one can analyze to determine the moments of time that are reasonable to each activity to begin and end. To estimate the project's duration determined based on the network critical path, simulation has shown the appropriate critical activities falling between the start and end times associated to them. The critical path is different for the sequences of activities that run from the beginning to the end of the project in relation with every problem to be solved. In our application there are several critical paths, between the beginning and end of the project, mainly are highlighted five critical activities common to all critical roads namely: identification of training needs, setting training objectives and content topics, and providing project support.

For each problem solved, the way that consumes the most time is the critical path, as highlighted time needed ***to complete the project and indicate which activities are critical to complete the project within the time allowed. Critical activities on critical roads should be the main concern of***

those responsible for human resource training, the time allowed to complete the training project. Any delay on critical path activities will extend the project duration and cost.

As shown in the table above, solving each individual problem highlighted roads and other critical activities, their precedence relationships, time and costs required to complete the training project (Rotărescu, E., 2010, pp. 468-475), (Rotărescu, E., 2011, pp. 46-56).

The materialization of the risk factors listed in b) and c) do not affect too much on the training activities themselves, but the critical task sequences that comprise critical roads and have a clear impact on the training cost and time. To shorten the training time could affect the training quality, problem that can be solved in the predicted time (10 days, 14 days) by the organization management in chossing the way regarding training, organization, tematical quality, trainer competence, methodology and the instrumental used in training etc., to realize the project training objectives, concomitently with the executing ot tasks induced by the context.

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