# Method of Project Management for Planning and Launching a New Product

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*Abstract:* **-** The paper presents a frequently employed method in project management, in an uncertain environment. The PERT method has proven particularly useful in cases when the manager has to compromise between the duration till completion of a project and its cost. The PERT algorithm is also presented, utilized in a network with arc representation of the activities. Lastly the paper exemplifies a solving variant of the problem of a company planning on preparing and launching of a new product on the market.

*Keywords*: - uncertainty, project cost, duration of completion, probability factor, critical path, project achievement probability by deadline

## 1 Introduction

The main method employed in project management is P.E.R.T. (Programme Evolution and Review Technique). It allows the planning of the activities and the determination of the probability of achieving the planned duration for a project, under circumstances when the durations of the activities are not known with certainty.

The PERT method is a stochastic model and is useful in situations when the manager has compromise between the duration of project execution and its cost. Such a relationship can be represented graphically as follows:

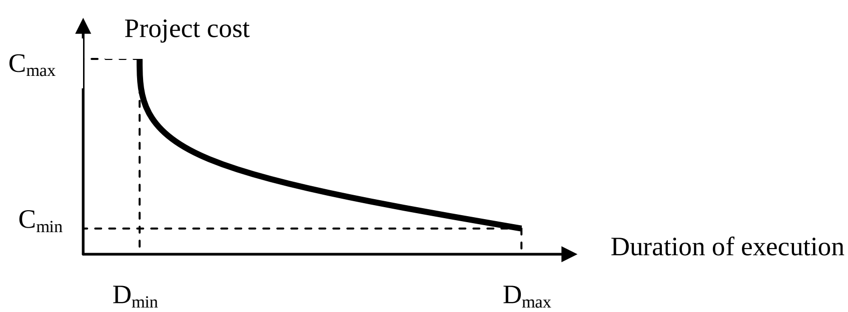


Fig.1 Relationship between project cost and its execution**.**

PERT is an analysis procedure of the critical path, which operates with durations that are not known precisely. A probability is assigned to each duration. These durations have to satisfy a certain law of distribution:

1.

1. They have to be limited (to exist within an interval) [A; B]
2. There needs to exist a most probable value
$m \in [A; B]$
3. $B - A = 6\,\sigma$, where
$\sigma$ - the mean square deviation.

The durations of the activities satisfy law$\beta$, which has a certain density of distribution.

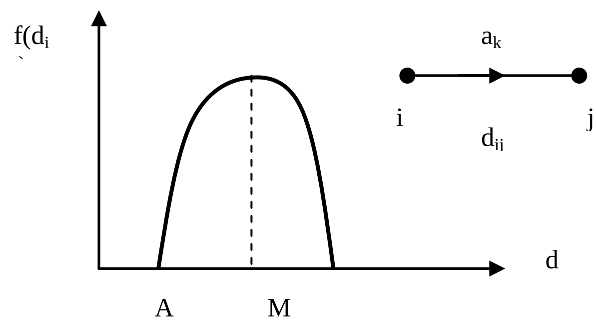


Fig.2 Density functions of variable ß.

where:

- limit of B – the pessimistic duration
- limit of A – the optimistic duration
- limit of M – the most probable duration

$$\bar{d}_{ij} = \frac{A + 4M + B}{6} \qquad (1)$$

and

$$\sigma_{ij}^2 = \left(\frac{B - A}{6}\right)^2 \qquad (2)$$

Considering the averages $d_{ij}$ as being constant, the C.P.M. (or M.P.M.) procedure can be applied for the calculation of the critical path. The PERT programme brings a new element, that is the probability of achieving the planned deadline (Tp) can be computed (A probability of confidence can be computed also for the intermediary time limits). The duration of the project is the same as the deadline for the final event, hence with the sum of the average durations of the critical activities. The deadlines of this sum are random variables due to the fact that a variable is attached to each probability.

The total duration T of the project is a random variable. It can be proved that the variable T has an approximately normal distribution, of average:

$$T = \sum_{(i,j) \in D_C} \bar{d}_{ij} \qquad (3)$$

and

$$\sigma_n^2 = \sum_{(i,j) \in D_C} \sigma_{ij}^2 \qquad (4)$$

In order to apply this hypothesis, the number of activities within the project has to be sufficiently large. If the hypothesis on the normality of the

A variable $\beta$ (PERT) – which is deduced from function $\beta$ with certain transformations has the following density function:

distribution is true, then the probability factor z can be calculated.

$$z = \frac{T_p - \bar{t}_n}{\sqrt{\sigma_n^2}}; \quad z \to \varphi(z) \qquad (5)$$

Knowing z, then from the table of the Laplace function the probability $\varphi(z)$ can be determined, corresponding to the computed value of z. The probability of duration T must not exceed the planned duration.

$$P(T \le T_p) = \frac{1}{2} + \varphi(z) \qquad (6)$$

The values comprised in the table of the Laplace function have the following significance:

a) $P(t_n \le T_p) < 0.25$: the risk of not meeting the deadline set for the completion of the project is very high. Hence the activities need to be revised and additional resources have to be allocated in order to reduce the durations.

b) $P(t_n \le T_p) \in (0.25; 0.5)$: there are chances of completion of the project in time. These chances are the greater, the closer $P(t_n \le T_p)$ is to the upper limit of the interval.

c) $P(t_n \le T_p) \in (0.5; 0.8)$: the programming of the project activities is correct. A good correlation is ensured between the utilized resources and the assumed risk in relation to meeting the deadline set for completion of the project.

d) $P(t_n \le T_p) > 0.8$: there are very high chances of completion of the project in time, with a relatively large consumption of resources.

The probabilities of achievement of the durations attached to the activities represented along the critical path can be computed in the same manner.

## 2 The PERT Algorithm

Typically a network is employed, consisting of the representation of the activities along arcs.

Step 1. The average duration of each activity is computed:

$d_{ij} = (A + 4M + B)/6$

Step 2. The deadline for the events is calculated by using the CPM method.
Step 3. The dispersion of each activity of the project is calculated.
Step 4. Calculation of $\sigma_n^2$ and $t_n$
Step 5. Computation of the probability of achievement of the total planned durations Z , $P(t_n \leq T_p)$
Step 6. This probability is analysed based on the criteria presented in sections a, b, c, d.

## 3 Practical Applications

A company intends to prepare and launch a new product on the market. The preparation and launching project of product E 18 includes 13 activities:

A1 Obtaining of financing for the project;
A2 Establishing the required personnel;
A3 Personnel recruitment;
A4 Market study (determination of potential markets);
A5 Determination of production capacities;
A6 Employment of personnel;
A7 Preparing of the logistic personnel;
A8 Preparing the personnel for direct marketing and of the own sales agents;
A9 Preparing and launching into manufacturing of the product;
A10 Setting up of the chain of stores;
A11 Preparing the transport network;
A12 Supplying the stores;
A13 Promotion and advertising.

As the unfolding of the project is a premiere, there is no experience to rely upon in predicting accurately the durations of the project activities. For this reason the project manager has established for *each $\alpha$ activity* three durations: an *optimistic* one $d_o(\alpha)$, a *pessimistic* one $d_p(\alpha)$ and one $d_m(\alpha)$ considered *the most probable*.

Table 1. Durations and interdependencies between the project activities

| Activity | Conditionings | Duration | | |
|---|---|---|---|---|
| | | Optimistic $d_o(\alpha)$ | Probable $d_m(\alpha)$ | Pessimistic $d_p(\alpha)$ |
| A1 | - | 2 | 6 | 10 |
| A2 | A1 | 1,5 | 3 | 10,5 |
| A3 | A2 | 2 | 3 | 10 |
| A4 | A1 | 4 | 6 | 8 |
| A5 | A3, A4 | 1,5 | 2 | 2,5 |
| A6 | A3 | 2 | 3 | 4 |
| A7 | A5, A6 | 3 | 3,5 | 7 |
| A8 | A6 | 4 | 6 | 8 |
| A9 | A6 | 5 | 8 | 11 |
| A10 | A7 | 2 | 3 | 4 |
| A11 | A7 | 0,5 | 1,5 | 5,5 |
| A12 | A8, A9, A10, A11 | 0,5 | 1 | 1,5 |
| A13 | A3 | 8,8 | 10 | 17,5 |

These durations as well as the interdependencies between the project activities are presented in table 1. Considering that the planned duration of the project $T_p$ is of 27 weeks, the following tasks are to be carried out: *planning* of the project *activities*, *identification of the critical path* and determination of the *probability of achievement of the planned deadline*.

**Solving:**

**Step 1:** We determine the average duration of execution for each activity d(α):

$$d(A_1) = \frac{2 + 4\cdot 6 + 10}{6} = 6 \qquad d(A_2) = \frac{1{,}5 + 4\cdot 3 + 10{,}5}{6} = 4$$

$$d(A_3) = \frac{2 + 4\cdot 3 + 10}{6} = 4 \qquad d(A_4) = \frac{4 + 4\cdot 6 + 8}{6} = 6$$

$$d(A_5) = \frac{1{,}5 + 4\cdot 2 + 2{,}5}{6} = 2 \qquad d(A_6) = \frac{2 + 3\cdot 4 + 4}{6} = 3$$

$$d(A_7) = \frac{3 + 4\cdot 3{,}5 + 7}{6} = 4 \qquad d(A_8) = \frac{4 + 4\cdot 6 + 8}{6} = 6$$

$$d(A_9) = \frac{5 + 4\cdot 8 + 11}{6} = 8 \qquad d(A_{10}) = \frac{2 + 4\cdot 3 + 4}{6} = 3$$

$$d(A_{11}) = \frac{0{,}5 + 4\cdot 1{,}5 + 5{,}5}{6} = 2 \qquad d(A_{12}) = \frac{0{,}5 + 4\cdot 1 + 1{,}5}{6} = 1$$

$$d(A_{13}) = \frac{8{,}8 + 4\cdot 10 + 17{,}5}{6} = 11$$

**Step 2:** We determine the critical path by one of the CPM or MPM method, considering for each activity α the average duration d(α) computed at step 1.

For the considered example the graph of the activities of project E 18 and the critical path determined by the CPM method are represented in Fig.3.

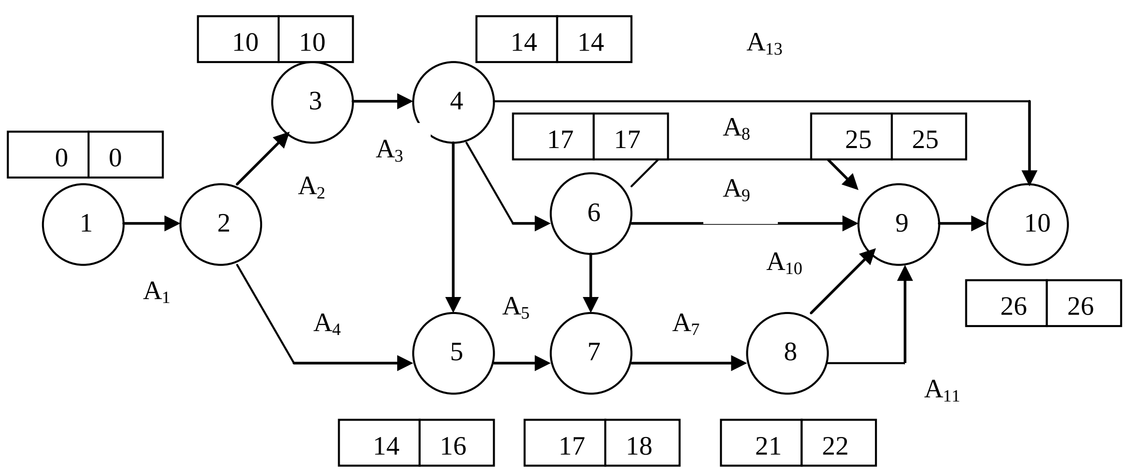


Fig.3 The graph of the activities of project E 18.

The critical path consists of activities A1, A2, A3, A6, A9 and A12 and its total duration is of 26 weeks. thus the average duration of the project is:

$t_n = 6 + 4 + 4 + 3 + 8 + 1 = 26$ weeks

The minimum and maximum dates set for the starting and completion of the activities, as well as the total reserves is presented in Table 2.

Table 2. The minimum and maximum dates set for the starting and completion of the activities

| Activities $\alpha$ | Conditionings | $d(\alpha)$ | $t^t_m$ | $t^t_m$ | $t^t_M$ | $t^t_n$ | $R_t$ | |
|---|---|---|---|---|---|---|---|---|
| A1 | - | 6 | 0 | 6 | 0 | 6 | 0 | critical |
| A2 | A1 | 4 | 6 | 10 | 6 | 10 | 0 | critical |
| A3 | A2 | 4 | 10 | 14 | 10 | 14 | 0 | critical |
| A4 | A1 | 6 | 6 | 12 | 10 | 16 | 4 | |
| A5 | A3, A4 | 2 | 14 | 16 | 16 | 18 | 2 | |
| A6 | A3 | 3 | 14 | 17 | 14 | 17 | 0 | critical |
| A7 | A5, A6 | 4 | 17 | 21 | 18 | 22 | 1 | |
| A8 | A6 | 6 | 17 | 23 | 19 | 25 | 2 | |
| A9 | A6 | 8 | 17 | 25 | 17 | 25 | 0 | critical |
| A10 | A7 | 3 | 21 | 24 | 22 | 25 | 1 | |
| A11 | 17 | 2 | 21 | 23 | 23 | 25 | 2 | critical |
| A12 | A8, A9, A10, A11 | 1 | 25 | 26 | 25 | 26 | 0 | |
| A13 | A3 | 11 | 14 | 25 | 15 | 26 | 1 | |

**Step 3:** We determine the dispersion of the duration of execution of the project, as being the sum of the dispersions of the durations of execution of the activities along the critical path.

$$\sigma_n^2 = \sigma^2(A_1) + \sigma^2(A_2) + \sigma^2(A_3) + \sigma^2(A_6) + \sigma^2(A_9) + \sigma^2(A_{12})$$

$$\sigma_n^2 = (\frac{10-2}{6})^2 + (\frac{10,5-1,5}{6})^2 + (\frac{10-2}{6})^2 + (\frac{4-2}{6})^2 + (\frac{11-5}{6})^2 + (\frac{1,5-0,5}{6})^2 = 6,943 \quad \text{weeks}$$

**Step 4**: We determine the probability factor z:

$$z = \frac{T_P - t_n}{\sqrt{\sigma_n^2}} = \frac{27-26}{\sqrt{6,943}} = 0,38$$

**Step 5**: We determine the probability of achievement of the project in time $p(t_n \le T_p)$. For this we determine from the table of the Laplace integral function for z = 0.38 the value 0.14803.

In order to effectively obtain the probability of achievement of the project $P(t_n \le T_p)$ we shall take into consideration that:

$$p(t_n \le T_p) = \frac{1}{2} + \phi(\frac{T_p - t_n}{\sigma}) \quad (7)$$

where

$$\phi(z) = \frac{1}{\sqrt{2\cdot\pi}}\cdot\int e^{-\frac{y^2}{2}}dy \qquad (8)$$

is exactly the integral function of Laplace.

Hence:

$$P(t_n \leq 27) = 0,5 + 0,14803 = 0,64803$$

Graphically this result is illustrated in Fig. 2.

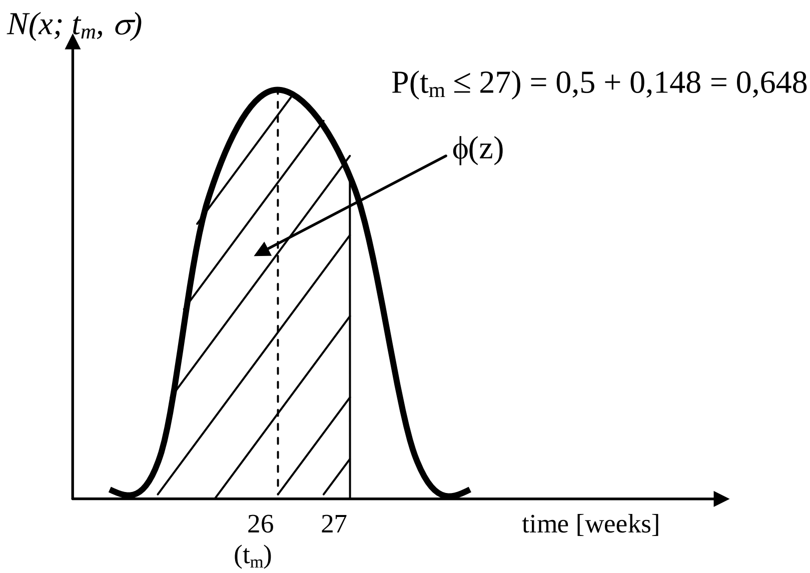


Fig. 2 Graphically results of the integral function of Laplace.

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