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Application of Probability Functions to Production Time Scheduling

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Abstract

The article analyses suitability of basic probability functions applied to production time scheduling. It points out relatively favourable approximation of normal distribution by a trapezoidal function within probability range applicable to production time scheduling which is suitable for shortening time of computation by a computer and adequate software application.

Keywords: a production, a time scheduling, probability, computing

Introduction

Modern industrial production is focused on producing goods for consumers with an aim to achieve the highest quality, the lowest factory price and the shortest production time as it is shown in Figure 1.

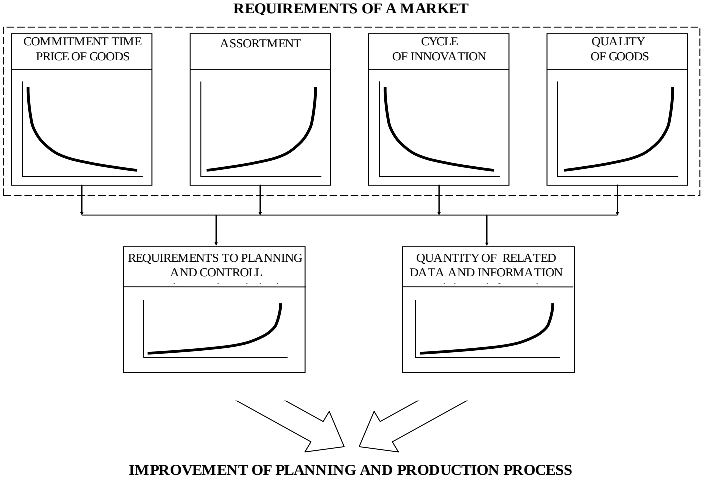

Fig. 1. Consequences of production activities relations

There are continuously increasing requirements to prepare a production process with higher quality, to decrease time of planning and creation of a production process scheduling for reasons given above. Even mass production produces only small numbers of the some products, at present, under the impression of various customer demands and possibilities to create final products by putting subcomponents produced by different producers together. This is a reason why production planning is getting near to project solving. However project solving is serious, time – consuming activity which without a computer with efficient software utilization is not practicable at today different production alternative requests.

Critical Path Method principles are used to solve projects, what enables to receive information about critical activities which have to be in a focus of interest of project realization, and time resources which by suitable planning can be used for different activities realization in addition. A disadvantage of this method appears in using discrete time data description of particular activities. These time data is possible to obtain with reasonable accuracy only for the activities measured many times, which in projects is not likely to happen. Even well-known activities are affected by lot of influences of the surroundings which do not enable to meet assigned times of the particular activities. Realization of a project with 100% probability would require spare resources overcharging project realization.

Probability functions using

For the activities that are new it is necessary to define time to their realization. There has to be carried out a professional estimation which probability is not known exactly too.

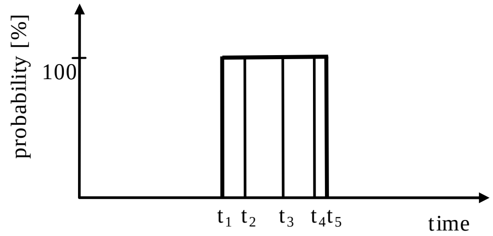

Fig. 2. Rectangle shape of probability function

Several different methods of estimation can be used, for example estimation by autonomous specialists, etc. Even then it is not evident which data should be used. If there are for example 5 different estimated time data for the planned activity, each of them is with probability significance 1, because we are not able to define in advance which of them is valid significantly. This results in probability function having a rectangle shape. Otherwise we would not have less significant data ordered, because it takes time and money.An arithmetical average of them can be computed, but it does not have to correspond with reality. This is a reason why methods which accept possible differences, Program Evaluation and Review Technique for example, are used. It uses optimistic time t_o, pessimistic time t_p and most likely time t_l estimations to compute:

Expected time:

$$t_e = \frac{t_o + 4t_l + t_p}{6}$$

Variance of the distribution:

$$V = \frac{(t_p - t_o)^2}{6^2}$$

by using β distribution. β distribution can be of different shape depending on values of the parameters. Computation of the expected time expresses that most likely time is estimated with 4 times higher probability than optimistic and pessimistic estimation of the boundary values. The highest probability is 100%. Optimistic and pessimistic times are considered than as ¼ of 100% that means they are considered on a level of 25%. It corresponds with opinion of the authors, who think, that the project prepared with a probability of realization below 30% should be revised, because it is irregular and its realization is indeterminate.

One of the possible solutions is using function of normal (Gauss) distribution located around the obtained estimates in such way, that it will approximate rectangle distribution (shown in Figure 1) as close as possible. That means that all estimates should be accepted with the highest probability. There has to be taken into account a distribution of the estimated values. None of the estimated values should have lower probability than 25% by the upper mentioned reasons. By The Six Sigma Method, which uses probability function of normal distribution too, into a variance ±1 sigma is included 68.26% of all values and a probability characteristics intersects the level 60.6%. The variance ±2 sigma includes 95.46% of all values and the probability characteristics intersects the level 13.5%. The projects elaborated with the probability higher than 75% are considered to be projects with redundant assurance binding more resources and being more expensive. Taking into account the reasons described above, there is a need to focus observation of values within limits 25–75% of the probability characteristics. There are different shapes of normal distribution probability function in dependence of the expected value and variance. It is convenient to transform the characteristics in way enabling to reach 100% at expected time when time of realization is needed to be known.

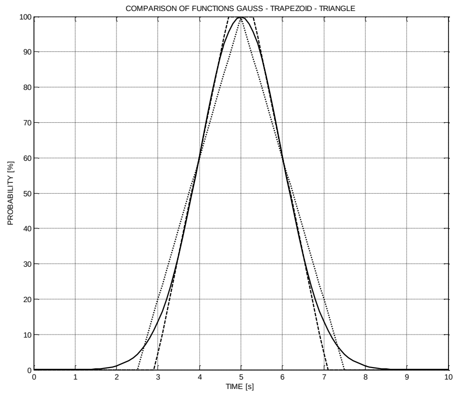

Fig. 3. Coincidence comparison of probability functions shape: Gauss, triangle, trapezoidal

Task solving by using computer with reliable software offers an opportunity to choose a shape of probability function for time estimates of the particular activities. The choice has an influence on computational accuracy and demands, what results in longer duration of computation. Using of Gauss distribution increases computational demandingness (power of computer) hence the simplified shapes application is suitable. Three values (optimistic time, pessimistic time and most likely time) leads to the triangle shape. The triangle shape is significantly different in comparison with the shape in which the all estimated values have the same level of probability 100% and Gauss curve moreover. Properly selected trapezoidal shape coincides considerably better with the probability function of normal distribution as it is shown in Figure 3.

Simplified shape probability functions application

Within the range of 28–90% of probability it is by a trapezoidal shape, in comparison with Gaussian curve, possible to reach a deviation within the limits ±1%. Within the range 90–100% values are slightly amplified with deviation up to +4% that means emphasizing effect of values in surrounding of the expected time. Below 28%, there are larger deviations, up to -11%, which means that influence of values with higher deviations from expected time is reduced in comparison with normal distribution curve. This is a zone with low probability of successful activities realization, which means a necessity to revise a project in terms of time estimation precision. Therefore it is not in a centre of the project solving.

The triangle probability function shape application on the contrary reduces (up to -8%) effect of values in surroundings of the expected time and it amplifies the effect of values (up to +8%) with higher deviation from the expected time, what is shown in Figure 4. This is a reason, why the triangle shape application is less suitable.

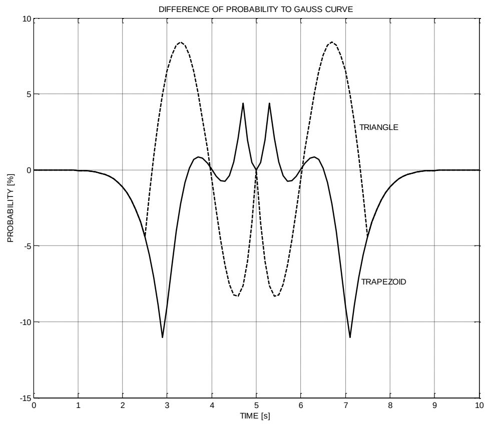

Fig. 4. Deviation of trapezoidal and triangle functions compared with Gauss probability function

As a matter of fact it is important to identify deviations between the trapezoidal and the triangle probability characteristics compared with Gauss curve in a horizontal orientation, it means time data (Figure 5). According to difference characteristics, adjusted by exactly defined time of particular activity, the trapezoidal function differs within 28–90% of Gaussian function only ±0.015 of the time defined by Gaussian function. Within 0–28% probability of Gaussian function, the time data determined by the trapezoidal function are longer in comparison with Gaussian curve. Within 90–100% probability of Gaussian curve, the time data determined by the trapezoidal function appear to be shorter. The time data determined by the triangular function are shorter within 5–60% (15–40% significantly shorter) than time data defined by Gaussian curve and longer within the range of 60–100% (80–95% significantly longer).

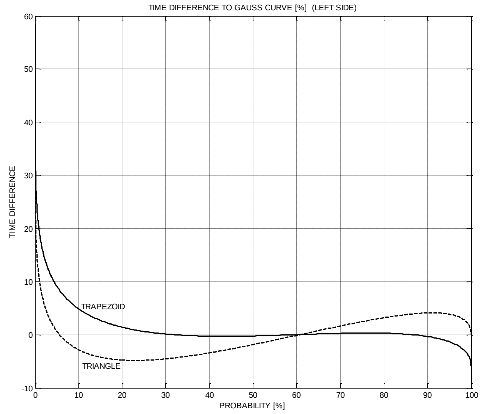

Fig. 5. A difference characteristics of time data expressed by percentages

The presented deviations adjusted by exactly defined expected time value of particular activity are expressed in percentages in Figure 5.

By comparison of time differences obtained by the trapezoidal and the triangular function of estimated time data it is possible to observe the following: the trapezoidal shape with properly designed parameters enables a significantly better approximation of Gaussian curve than the triangle shape and essentially decreases computational requirements.

Conclusion

The article describes a comparison of the trapezoidal and the triangle probability functions with Gauss curve to define partial activities time of a project. Extension and shortening of time values obtained by the trapezoidal and the triangle functions, shown in Figure 5, 6 express that the trapezoidal function corresponds much better with normal distribution than the triangle. A visualization of differences oriented in the direction of time axis expressively describes considerably better approximation of Gauss curve by the trapezoidal than by the triangular function. In a range of interest within 28–90% there is a divergence ±0.3% of expected time value. In this way a reader can receive information about applicability of different shape functions which define times duration of the particular activities in a project.

References

Chvalovský, V. (2005). *Řízení projektu aneb překážkový běh na dlouho utrať*. Praha: Aspi.

Slack, N., Chambers, S., Johnston, R. (2004). *Operations Management*. London: Prentice Hall.