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Mathematical mode linproject time and cost estimation

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ABSTRACT - Businesses will also build revenue through creativity as well. In today's information-based culture, The ability of humans to generate economic gain changes from physical to intellectual labour. Structures for the method that are innovative and radical. It covers issues such as fundamentally changing basic market practices by introducing a process-oriented approach to business and using modern technologies and techniques. Efforts to improve market efficiency and creative efforts to minimize the prices of goods and services are described as all types of cost-cutting advances in manufacturing processes.Nowadays, businesses cannot provide competitive advantage only with cost. The response time of the enterprises to the market requirements has been the life cycle of the product produced, its nature and special product. Nowadays, businesses want to have the ability to carry out more than one project at the same time, but this situation requires businesses to have innovative project management skills other than traditional project management techniques. Innovation of the concept of entrepreneurship in modern businesses.It can be defined as ensuring the continuity of understanding.

Keywords: Project Management, Mathematical model, LinearProgramming

I. INTRODUCTION

Because the activities in organizations become simultaneously manageable, the number of hierarchical layers in management decreases. Especially in production enterprises, the concept of project-based production management is widespread and the project organization, budgeting, scheduling, project follow-up means to support functions are increasing. In project management, the observation of resource constraints during the chart of simultaneous activities is a suitable approach to the solutions to real-life problems.

The project, which is one of the main processes of the organization, if the organization consists of the processes carried out by certain periods and the project can be rescheduled, the improvements of the processes that make up the project can be made. The activities that restrict the functioning of the project, reducing activity and efficiency, not creating an added value, the loss of time, time, and the cost increase, are examined by determining, measurements can be made to improve the necessary improvements. It is stated that the complexity of projects carried out in production enterprises are difficult to manage these projects without any software tool.

The project management is defined as planning, organization, managing, coordination and control functions in order to access the aims of an organization in the production, trade or service sector. Planning and scheduling project activities has an important role in control of project performance. One of the approaches applied to the effective use of the project budget, the cost of a product or service is the cost of the cost of all activities required to produce the product or service with the cost of the raw material and the cost of the raw material. Project Cost Management is the method of lowering project costs while retaining project scope and efficiency levels within the project's appropriate time frame. The reduction of costs with the project management, increasing the quality, the effective realization of the business time plan is to be carried out in the targeted budget limits of the product. Project Management Systems; It consists of combination of processes, tools, resources and methods to manage the project.

Processes Converts a specific entry to a specified output, while projects transform the input into the outputs within the framework of specific time, cost and scope.

From this point of view, projects are brought together by planning the processes and activities in a logical order. With these properties, sub-processes and activities containing the main process of an organization within the scope of the projects and the process flow schemes can be created by collecting information on these activities.

Project-oriented enterprises must take permanent measures by reviewing their past experiences to eliminate disruptions in the current

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project management processes. The standardization of the basic steps in the Project Management Processes will allow the process to be carried out in a healthy way, but then the project time and project costs are possible to make consistent predictions. This study was carried out in an industrial enterprise in the automotive side industry sector in Bursa, special machine design and manufacturing projects were carried out. The relevant section performs processes such as special machinery manufacturing, testing technologies, after-sales services within the enterprise. In the business

Mounting line production has been made in production processes of studies because the total production includes 45% of the production. In the enterprise, the installation line production is observed in the project management processes between the values determined during the project bidding phase and the values that occur during the realization of the project. This study is the examination of the deviations in the projecting processes, cost calculations and engineering times as a pilotand covers the stages of standardization.

In the following sections of the study, the literature was investigated first related to the subject and then the methods used in the study are briefly explained. In the section where the application is revealed, it is primarily analyzed the existing project process in the enterprise and the problems of improvement are presented. A mathematical model specific to the project process

The optimum completion time of the process is calculated, developed decision support system with an innovative tool in projecting process management. In the last chapter, the results obtained at the end of the study and recommendations for future studies are included.

II. LITERATURE REVIEW

The project management is a management methodology developed for the effective management of project activities as soon as possible, in the lowest cost, the highest quality is necessary for the effective management of the equipment, machine, knowledge, ability and other resources. Project Management The probability of successful completion of projects in the enterprises helps the use efficiency of different resources and international communications. From this point of view, it is related to project management in the literature

It is seen that many research is made. In the project management processes, they investigated the internal entrepreneurial relationship and determined the dynamics that affect strategically organizational performance in their studies.

YU stated that strategic project management has supported agility and functionality in enterprises. One of the proofs of the relationship between project management systems and corporate entrepreneurship is both the organizational environment and both affected and affected. Fonrouge VD stated that entrepreneurship and project management contained similar problems and practices related to sustainability, environmental concerns, resource efficiency, innovation, computing and technological management. A successful project management tool will improve businesses to improve the ability of businesses.

The first studies on the development of project planning and programming techniques come across the end of the 1950s. The basic methods developed in this regard are Gantt diagrams, PERT and CPM. The important thing in PERT is to determine how long the project can be completed, while in Pert / Cost, which is a different form of Pert, is to reveal the information about the cost of the project. In this art, the cost estimates are made in the event of the costs and the time is minimum if the cost for each activity is minimum.

When the historical development of PERT is examined, Gantt diagrams are found to be based on PERT. However, the Gantt diagram is a method that can show the relationship between the phases of the work to be made. Therefore, a more advanced form of Gantt diagrams may also be called pert. Methods such as PERT and CPM are limited to the use of many real problems since they perform the solutions in the case of unlimited resources.

The source-limited project scheduling problem (SLPSP) is that the activities that make up a project using restricted resources are scheduled to optimize the aim function without violating priority relations. The source-limited project scheduling model may be different in the scheduling model, it may be different to be available and each event needs a certain amount of resources to the realization and the relationship between activities can be found. The purpose of the model is the project completion under the constraints of activities, activities, activities and resources use.

It is to determine the start and ending times that gives the appropriate chart to least. The Welding Capacities in the Classic Resource Restricted Project Scheduling Model are constant and the activities are considered to be divided.

In general, it is always a desired target of completion times completion times in project

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management systems. As a result of the literature research, the single-mode welding-limited project scheduling formulation was the most appropriate model for the project management system. To obtain optimum solution of single-mode welding-restricted project scheduling problem.

The mathematical model for the established mathematical model will be used for the smallest of the projecting period. The number of workers used in the work required in the project in the project is restricted by the total number of workers in the project. In order to start any event, it is necessary to finish the leading activities, and the necessary resource is available in the relevant time range. The properties of the project, such as welding constraints and operating priorities, defines the restrictions to be followed during the project period.

In this study, an automotive side industry has been developed to reduce the problems in the projecting process, which is a real problem in the projecting process, using methods applied in the studies in the literature research. Therefore, the work done, developed in the field of project management.

It is assessed that the methods will contribute to the project managers of both literature and in real life related to the implementation of real life.

III. RESEARCH METHODOLOGY

In this study, various recommendations have been developed to reduce these problems by determining the problems that are analyzed in the field of automotive side industry. In addition, a project management tool will also provide at the conclusion of the report, good project management was shown.The project management steps used in the study are shown in Fig 1.

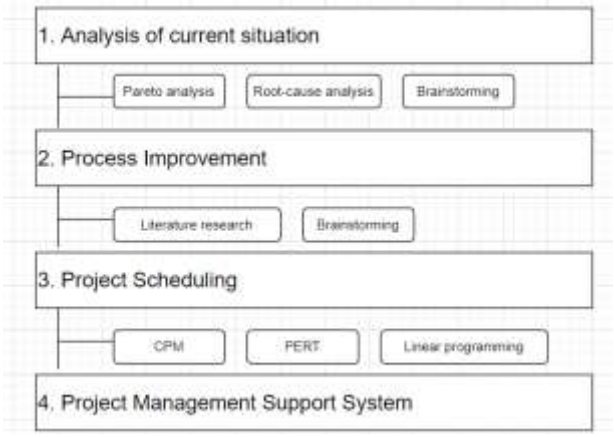

Figure 1. Project management stages and methods used in the study

The information on these stages is given below.

1) Analysis of current situation: Pareto analysis and root-cause analysis methods were applied to the emergence of the project's projecting process.
2) Process Improvement: To reduce the problems detected from the current status analysis, the duties and responsibilities in the project steps are reviewed, job definitions and business departments are re-arranged.
3) Project Scheduling: The activities required for the completion of the project were determined, the priority of the project activities between the project activities and resource requirements, the mathematical model is formed to draw the project to be completed as soon as possible.
4) Project Management Support System: Effective Management of Project Process for the possible cost of future projects as soon as possible and at the lowest cost a project management tool is developed to ensure that all project records are ensured thanks to this tool.

Within the scope of the method specified in the third section, an application was carried out in an enterprise operating in the automotive supplier industry. The four steps of the process described above were applied consecutively, as there was no previous improvement work on the project management processes in the business in question.

A. Analysis of current situation

First, the current situation of the project management process has been analyzed. The company's current assembly station project planning process; demand collection, review of requirements, preparation of technical concept, preparation of cost planning, creation of time plan,

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risk assessment, preparation of proposal formand forwarding and customer calls.

In order to analyze the current project design process, 47 important assembly line projects were selected in the past, and a survey was conducted with eight different project managers who managed these projects to find the source of the problems related to these 47 projects. When the survey results are examined, the main reasons for the deviations in the project design process; problems in the organizational structure, the correct timetableand the cost planning tool is inadequate.

Based on the data obtained from the survey study, the causes of the problems observed in the project design process were determined with the Pareto Analysis method. When the results of the Pareto analysis in Figure 2 are examined, the first problems to be examined are the failure to determine the engineering and workmanship times properly, the time determination according to the experiences and the material prices.

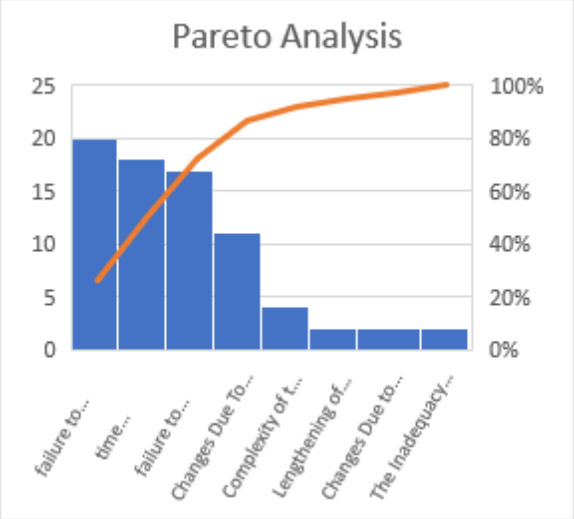

Figure 2.Pareto analysis results

As a result of the brainstorming study carried out by a mechanical engineer and five industrial engineer titles in the enterprise and system analysts, sub-elements in Figure 3 were determined under these main headings according to their importance.

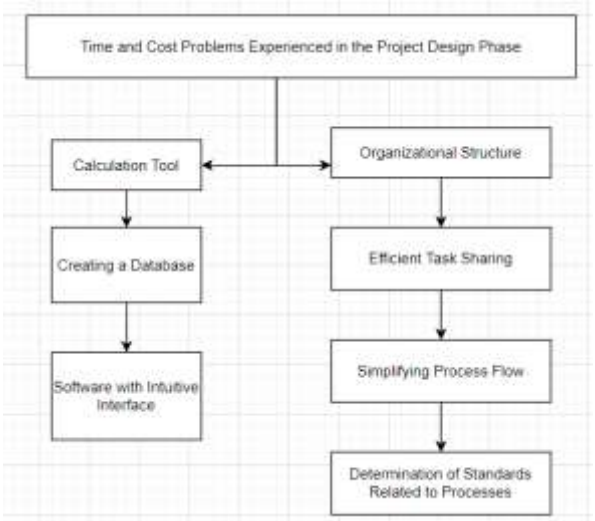

Figure 4. Problems encountered during the projecting process

After the current situation analysis studies, the reasons for the problems observed in the enterprise. It has been determined that the division of labor in the enterprise may be insufficiently defined, cost planning takes a long time, the tool used in cost planning is not flexible, the calculation

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tool is dysfunctional, the database is not available and the data can be entered manually.

B. Process improvement

Following the analysis of the current situation, the measures in the literature for the solution of the observed problems were examined. Afterwards, a brainstorming study was carried out with the process manager and system analysts in the enterprise and the following measures were recommended to be taken on the existing project management process of the enterprise for process improvement:

- Sorting out the process steps that the project leader is not required to be involved in.
- Reducing the number of work steps carried out by the project leader himself.
- Establishing a balanced division of labor among employees.
- The process steps that do not have priority relations between them are started to be carried out in parallel.

C. Project Scheduling

The single-mode resource constrained project scheduling model was used to determine the duration of project planning carried out under resource constraints more realistically. Resource-constrained project scheduling problem tries to ensure that the activities that make up a project are completed in the shortest time possible with the use of limited resources in accordance with the priority relations. In the current situation, according to the activity information given in Table 1, it has been determined that the project planning process (the time between the receipt of the project-related request and the submission of the project proposal) takes an average of 47 days by using the CPM method.

The activities in Table 1 are calculated by taking the average of the time between the receipt of the request for the project and the submission of the proposal, and the most optimistic and pessimistic periods for 47 projects. While analyzing the problems faced by the company during the project design process, it was determined that some of the activities in the project design process were activities that can be carried out simultaneously, and in this case, it was observed that the average 47-day project proposal preparation period calculated for the project design process was not a competitive value.

Table 1.Predecessors, start and end times of the activities

Activities	Predecessors	Time	Start	Finish
Demand collection	-	1	0	1
Review	A	3	1	4
Technical concept	B	26	4	30
Time plan	B	11	4	15
Cost plan	B	27	4	31
Risk assessment	C, D	2	30	32
Proposal form	D, E	7	31	38
Evaluation meeting	F	4	32	36
Submission of the offer	G, J	6	38	44
Bargain	J	3	44	47

Within the scope of organizational structuring, models aiming to minimize the project delivery time in project management have been emphasized and it has been determined that the resource-constrained project scheduling approach is the most suitable model for the project management system. The mathematical model created in this direction is explained below:

i, k: Activity index (i, k = 1, …, I)
t: Time index (j = 1, …, T)
j: Resource index (j = 1, …, J)

Parameters:
D_i : i duration of activity,
S_{it} : 1 if event i starts at time t, otherwise 0
q[i, j]: 1 if source j is used in event i, 0 otherwise,

Decision Variables:
E_{it} : 1 if event i ends at time t, 0 otherwise
prec[I, k]: 1 if event i is the antecedent of event k, 0 otherwise

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Mathematical Model

$$\min z = \sum_{i=1}^{I} \sum_{t=1}^{T} t * E_{it} \quad (1)$$

$$\sum_{t=1}^{T} t * S_{it} + D_i = \sum_{t=1}^{T} t * E_{it} \quad \forall i \quad (2)$$

$$\sum_{t=1}^{T} E_{it} = 1 \quad \forall i \quad (3a)$$

$$\sum_{t=1}^{T} S_{it} = 1 \quad \forall i \quad (3b)$$

$$\sum_{t=1}^{T} t * S_{it} + D_i \leq \sum_{t=1}^{T} t * S_{kt} \quad prec[i, k] = 1 \quad (4a)$$

$$\sum_{t=1}^{T} t * S_{it} + D_i \leq \sum_{t=1}^{T} t * S_{kt} q[i, j] = 1, q[k, j] = 1 \quad (4b)$$

$$E_{it}, S_{it} = \{1,0\} \quad \forall i, t \quad (5)$$

In the equation (1) in the mathematical model, there is an objective function that minimizes the completion time of the project design process. Equation numbered (2) shows the activity time limitation and activity i, S_{it} after starting on time$D_i$continuing for the duration andE_{it}shows that it ended on time. Equations (3a) and (3b) are just the beginning of activity i. (S_{it}) and an end (E_{it}) guarantees that he has his time. Equations (4a) and (4b) have priorityare constraints, and if activity k comes immediately after activity i, the start time of activityiS_{it}, D_i time unit before the start time of the activity k It provides (4a). Equation (4b) ensures that the use of resource j in activities is in accordance with the priority matrix. Equation (5) shows that the decision variables used in the model are binary integer variables.

IV. RESULT

Project Management Support System

The inefficiencies of the current calculation tool were identified during the system analysis phase. These shortcomings lead to user-induced errors due to the complexity of the current calculation tool interface and the lack of a database. For this reason, a software associated with the created database has been developed. While calculating the cost with the software developed based on MS Access.

Care was taken to ensure that all the required information is easily available. With the help of the tables created, the data can be entered in an easy and standard way and a dynamic structure has been created to prepare the project proposal.

A VBA-based heuristic algorithm was written on MS Excel in order to apply the mathematical model created in order to find solutions to the problems and loss of time in the project design activities of the company.

Each time the algorithm runs, it schedules for two situations. The first of these is the chart assuming that employees work with 100% performance. In this chart, activities are selected by reading from the priority matrix in order to identify and schedule the activities that do not have a precedent. If these selected activities do not have any restrictions for the employee, they are started to be scheduled at the same time. If there is a common employee in these activities, the first activity and then other activities are scheduled. After the first activity scheduled, the priority matrix for the next activity is re-read, and the start time of all activities with this first activity as its predecessor is taken as the end time of the scheduled activity. For all activities with the same beginning and predecessor, the persons involved in that activityattention is paid to the employee constraint by reading the matrix it creates. Since an employee cannot work in more than one activity at the same time, one of the parallel activities belonging to the employee is selected as the first activity. Until the algorithm reads the last activity time, it repeats the first three steps and ends with the scheduling of the last activity.

The second chart is the one assuming that employees work in more than one project and taking into account the occupancy rates of the employees. Occupancy rates are entered in the relevant line in percent. Unlike the previous one, in the table where the occupancy rates are taken into account, the highest occupancy rate is selected by looking at the occupancy rates of the employees working in that activity at the beginning of the algorithm. This ratio selected is multiplied by the activity time and added over the activity period again. The aim here is to make the scheduling process according to the busiest employee and to get realistic results. The next steps include the algorithm steps described in the first chart. Information on the basic activity periods and the duties of the employees in the activities are included in Table 3. Project resources (project leader, electrical designer, mechanical designer, production, purchasing) in Table 3 take the value "1" if used in the related activity and "0" if not used.

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Table 3. Time of activities in the new situation

Activity	Time	Premise	Project leader	Designer	Production	Buyer
Demand Collection	1	-	1	0	0	0
Review	3	A	1	1	1	1
Technical Concept	10	B	0	1	0	1
Time Schedule	5	B	0	1	0	1
Cost Plan	6	B	0	1	1	0
Risk assessment	3	C,D	1	0	0	0
Proposal form	1	D,E	1	0	0	0
Evaluation Meeting	4	F	0	1	1	1
Submission of the Offi	1	G,H	1	0	0	0
Bargain	3	I	1	0	0	0

While creating the database, a standard study is regularly provided by considering up-to-date information. This database is connected to the user interface programmed with MS Access. At the same time, the resource constrained project scheduling algorithm, which was developed, was also added to the software. As a result, a project management tool has been obtained where resource occupancy rates can be seen, proposals can be made, reports can be created for management and customers, and how many days the project can be predicted.

According to the implementation plan, it is envisaged that the database will be updated at regular intervals, the actual project planning times will be measured, and measures will be defined when necessary so that the measures implemented according to the implementation plan continue to be valid and similar problems do not occur in the future. In general, the project target has been achieved by providing 60% efficiency increase in capacity utilization during the project design process. The results obtained are summarized in Table 4.

Table 4. The effect of reduced engineering usage on working hours

	Project leader	Design	Buyer	Blue colllar	Total
Current situation (ho	387	252	54	162	**1107**
Developed situation	162	108	27	27	**441**
Savings amount (hou	225	144	27	135	**666**
Savings amount (%)	58,14	57,14	50	83,33	**60,16**

V. CONCLUSION

When the current work flow of the project design process in the enterprise is examined, as a result of the PERT technique applied, the completion time of the project design process was determined as 47 days. The late delivery of the offer to the customers delays the time schedule and causes customer dissatisfaction. A new organizational structure has been created by determining the activities that can be carried out simultaneously. Considering the new organizational structure, the project design process was examined with the PERT technique and it was determined that the time was reduced to 24 days. With the new organizational structure created, the project planning process has been reduced by approximately 49% on a daily basis.

In this study, an innovative project management tool was developed and its benefits were observed by applying it in a real enterprise. As a result of the studies carried out, a gain of 49% was achieved in the critical path calculation of the assembly line project design process, and an increase of 60% was achieved in the capacity utilization of the project design process. The gains obtained are of the nature to increase the competitive power of the enterprise. In the long term, thanks to the gains achieved in the project design process. The efficiency of using operational resources will increase. Thanks to the database created in the developed project management tool, the material groups and components have been standardized, and this information is easy to access.

In the project scheduling model included in the project management tool, only the employee constraint is considered as resource constraint. In future studies, situations where different resources such as time and equipment are limited can be integrated into the model. With the software developed within the scope of this project, both the project proposal process was shortened and the project proposal was sent to all users by a single tool.As it will be revealed, the accuracy and precision of the information regarding the cost and time planning of the project has increased. The project management tool created has ensured that the errors and deviations that may arise are minimized by standardizing the time plan and cost calculation steps during the project design process.

REFERENCES

[1]. Belfort, A.C., Martens C.D.P. ve Freitas, H.M.R. (2016), "Entrepreneurship in projectmanagement systems: proposal of a model and preliminary empirical evidence", Journalof Information Systems and Technology Management, 13(3), 405-422

[2]. Blazewicz, J., Lenstra, J.K. ve Kan, R. (1983), "Scheduling subject to resource

constraints: classification and complexity", Discrete Applied Mathematics, 5(1), 11-24.

[3]. Cheng, J., Fowler, J., Kempf, K. ve Mason S. (2015), "Multi-mode resource-constrained project scheduling problems with non-preemptive activity splitting", Computers andOperations Research, 53, 275–287.

[4]. Fonrouge, C., Bredillet, C. veFouché, C. (2018) Dialogic conversation and Luhmannian perspective", International Journal of Managing Projects in Business, https://doi.org/10.1108/IJMPB-01-2018-0013.

[5]. Lawler, E.L. (1976) Combinatorial Optimization: Networks and Matroids, Holt, Rinehart and Winston, New York, N.Y.

[6]. Martens, C.D.P., Carneiro, K.D.A., Martens, M.L.Silva, D. (2015), "Relationship between entrepreneurial orientation and project management maturity in Braziliansoftware firms", Journal of Strategic Management, 14(2), 72-91.

[7]. Ng, J.J. (2018), "A Deeper Look Into a Project Management Tool: The Change Register", IEEE Engineering Management Review, 46 (1), 24-26.

[8]. PMI. (2013), "A guide to the project management body of knowledge (PMBOK®guide)", United States: Project Management Institute, Inc.

[9]. Rad, P.F. Levin, G. (2002), The Advanced Project Management Office: A Comprehensive Look at Function and Implementation, Boca Raton, FL: CRC Press.

[10]. Valls, V., Quintanilla, S., F. (2003), "Resource-constrained project scheduling: A critical activity reordering heuristic", European Journal of Operational Research,149(2), 282-301.

[11]. Yu, F. (2012), "Strategic flexibility, entrepreneurial orientation and firm performance:evidence from small and medium-sized business (SMB) in China", African Journal of Business Management, 6(4), 1711-1720.

[12]. Zdanyte˙, K.Neverauskas, B. (2012), "Selection Appropriate Project ManagementTool for Advanced Organization", Economics and Management, 17(2), 782-787.