Product cost planning in pre-production stages

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Abstract

Due to current globalization and technical development, which is meant the growth of Industry 4.0, it is necessary to focus on technical areas, like research and development. Industry 4.0 is currently on the rise and will be constantly expanding over the coming period. For this reason, many physically demanding positions could gradually vanish, and a lot of new positions will need to be secured. The whole process, starting with marketing, planning, research, development through prototype production, serial production, quality control, packaging, distribution, creation of manuals or instructions, service and use of the product, till final recycling or disposal will need more of the Industry 4.0 strengths. Based on these facts, sectors like engineering will be under more pressure in process of invoicing and project management. This, is why this segment needs to improve productivity, flexibility, quality and more focus on the customer's target. Only if the engineering companies manage these elements, then they can remain competitive.

Key words: Engineering; projects, planning; costs; tool; productivity

1. Introduction

Product research and development is one of the most important phases of the live product because in these stages, the product is formed and managed. In another case, the companies which work on the project for product research or his development are more focused on the project than the product.

In this situation, it is necessary to setup and secure the project before its start and after. It is important to manage project entirely until completion. It has been stated, "Strategic costs may reach up to 40% of target costs in some sectors such as the automotive industry. An important limitation of target costing is the fact that it is working with future, estimated costs and expected production volumes,, [1]. Due to this information and the situation on the engineering market, it will be necessary to focus our efforts on project planning and whole project management, because research and development uses this part of strategic costs. The main reasons for this are costs saving, project target, project plan accuracy and productivity because these elements can significantly influence the project success and its margin. Because the project margin and project success are the most important areas for the company, which divides the gainfully companies from lossy and hardly surviving ones, it is important to focus on them.

1.1. Current situation

1.1.1. Modern cost management methods

Between modern cost management method, there are two representatives. The first one is Target Costing (TC) and the second one is Life-Cycle Costing (LCC) [2]. These two methods are similar, but each one has specific parts and rules which separates them. First, the focus is on the customer with their needs and wishes, which is one of the most important rules in our globalized market. However, many companies are not using it. The second one is the cost decomposition to each part or task, which we need to understand the whole product character, purpose and creation for the bill of material (BOM) with their costs. Finally, the one element which we can use for better effectiveness of our project is the type of cost reducing process. This process is created as a benchmark of project planning cycles and will be describe below. The TC method has often been used in a lot of manufacturing companies since the early 1960s. Many large companies in North America and Europe have tried to adopt target costing to enhance their cost management and, thus, it has increased their competitiveness. Consequently, many variations of target costing have been developed and are being used in different countries. Since TC, like many other management practices and philosophies, which is environment-specific, it is not surprising to see these variations in practice [2]. There are many published articles with different views on this philosophy, but many of them were aimed at the manufacturing process of product and cost reduction in pre-production stage. Nevertheless no one tried to apply the core elements of these methods for a different view and that is engineering environment as a processor of design work.

1.1.2. Engineering environment

Engineering environment is specific by the kind of work. Most of the work is formed by the hourly rate of the designer which includes his hourly rate, license fee and overhead costs, but this overhead cost depends on the size of the company and other factors. What is important in this case is the whole hourly rate and use of this rate in practice. In most cases, the hourly rate influences the project margin and for this reason, workers deployment and their productivity is important for success whole project. However, we can influence it significantly before the project start by a relevant analysis of the project.

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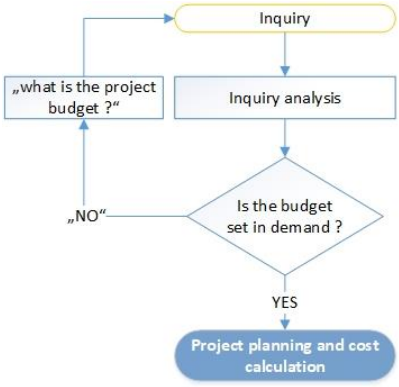
2.1. Product cost planning in pre-production stages

1.1.1. Process-weighted product development

Product research and development in engineering in globalization and the growth of Industry 4.0 instantly pushed towards faster project completion, better quality of the project outputs and even for the project cost savings. Due to our globalization most of product manufacturing companies can share their product development work, and they are pushed to this kind of outsourcing, according to their productivity and stable work flow. For this reason, manufacturing companies are before decision: "make or buy?". According to this situation a lot of engineering companies have opportunity to fulfill their requirements if they have enough know-how and sources. But the engineering market changed a relationship between the customer and supplier. Due to this condition, negotiation must be more different and focused on the customer options. As we see on picture 1. the project budget must be known before the project offer processing.



***Picture 1**. Basic cost determining process [Own design]*

Only after this situation is the project manager able to propose a correct project plan with all necessary tasks and inputs. Because if we want to use the TC methodology and TC main equation, we need to know the customer options and his main goal, and only if we use this kind of process we´ll can create appropriate relationship with our customer and we´ll be able to deliver him required product or service. Based on these facts we can use the TC equation as you see on picture 2.

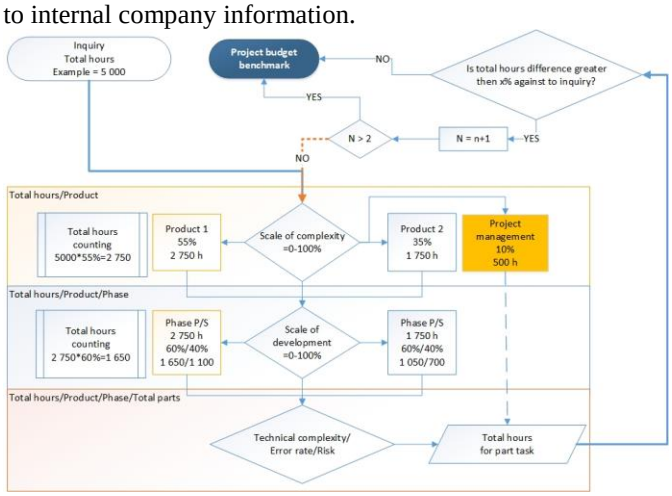
Target Cost = Sales Price – Target profit

***Picture 2.** Main TC equation used to project approach [3]*

After this we know the target cost which we must use to find appropriate quantity of company work and other sources which we´ll need to fulfill the project goals. We can use the process-weighted project development tool as you see on picture 3. to find correct quantity of company work. This tool is designed to use the scales for hour volume allocation. Whole tool process is designed to divide total hours to each product, development phase, development stage and each part of this stage. Because each part has different development process, we must edit each product, phase or stage according to the real requirements of customer and make frame for each project. This state we can use to next step of the process-weighted project development tool, where we must assign the main three variables:

1. Technical complexity (T_c)
2. Error rate (E)
3. Risk (R)

These three variables have different inputs according to their character. The first one on technical complexity has internal characteristic, because it depends on the character of the product and each part or each task of the product and reflects the technical difficulty of the product. Nevertheless, it also reflects company workers productivity, also company know-how and ability to manage this kind of project. So, this variable technical complexity must be evaluated and allocated only by the experienced manager who knows the company environment and have a access to internal company information.



***Picture 3.** Process-weighted project development [Own design]*

Error rate is another variable which has internal characteristics too like the previous one, because the error rate depends on a lot of workers abilities like their precision, output quality or accuracy of each company worker.

Risk is only one variable which has external character, that is connected to the customer goals and requirements.

These variables significantly can influence the project result and according to this state, the project manager who modeling the project plan with this tool, must know the impacts of his decisions. Certainly, it is better to assign each variable according to the real allocation of the company workers, but it is not a tenable state, because the actual allocation can be changed every day due to the real situation of the other company projects. For this state is more optimal to use company, department or team average value, which is more accurate to the real state.

The one of Process-weighted project development conditions is also the project hours budget difference cycle. Each company must choose the project hours budget difference between the inquiry requirement and tool counted output for setting rules of this process. This difference parameter can significantly influence the project

impacts and should create acceptable risk to company, not just in terms of impact to company as whole, but especially with aim to customer, his requirements and with a focus on project security. Within the whole processing is included premise of tool using with three minimal cycles of project plan hours counting and their benchmark. Which leads to more project plan options and the optimization of the project flow, which lead to project effectivity and cost savings. Each user of the project calculation tool must approach to this with project environment knowledge and with responsibility for the successful completion of the project.

1.1.2. Process-weighted product development tool testing

Actual tool testing process still brings a lot of questions which lead to better tool specification and his accuracy. This tool is developed to fast and transparent project planning allocation of hours budget with quantitative rating. All necessary inputs are yellow in color and their volume is limited only to main inquiry hours budget, main three variables and setting the weights as you see on picture 4.

	Input	Output
		Inputs
Input	3750	3 750,00
General technical complexity	105%	
General error rate	110%	
General risk	115%	
Products complexity scale	Max = 100%	
Product 1	55,00%	2 062,50
Product 2	45,00%	1 687,50
Product 1 development phases scale	Max = 100%	
P1 - Prototype	60,00%	1 237,50
P1 - Series	40,00%	825,00
Product 2 development phases scale	Max = 100%	
P2 - Prototype	60,00%	1 012,50
P2 - Series	40,00%	675,00
Summary	Max = 100%	
Summary		3 750,00

Picture 4. *Actual tool testing input. [Own design]*

The whole process of project outputs calculating must be defined by the project and set by the project manager. Only after this step is whole project planned correctly, and can bring to us an accurate look on the whole project its difficulty as you can see on picture 5.

Management	Engineering 2D	Check	Management output	Eng. 2D output	Project phase sum	Delta Inp/Out
			Outputs			
Max = 100%	Max = 100%					
15,00%	85,00%	OK	185,63	1 192,61	1 378,23	-10,21%
15,00%	85,00%	OK	123,75	795,07	918,82	-10,21%
Max = 100%	Max = 100%					
15,00%	85,00%	OK	151,88	975,77	1 127,65	-10,21%
15,00%	85,00%	OK	101,25	650,51	751,76	-10,21%
Max = 100%	Max = 100%					
			562,50		4 176,47	-10,21%

Picture 5. *Project planning tool outputs. [Own design]*

Development of main frame of each stage is crucial for creation accurate model of development process and for quality outputs. Each stage contains different quantity of tasks and only if is the number of tasks specified correctly, then for the processor tool can bring accurate output value for each stage.

3. Equations and mathematical expressions

The basic equation describing the relationship of the project and its calculation is below.

$$P_J = \sum_{i=1}^{n} P_{Di} \quad (1)$$

Where:
P_J ... is a project
P_{Di} ... is a product that contains a subset of phases (P_{Pi})
P_{Pi} ... is a development phase that contains a subset of stages (S_i)

$$P_{Pi} = \{S_1;\ S_2;\ S_3; \dots S_n\} \quad (2)$$

The main equation of the stage:

$$S_i = PN_{ij} * T_{Cij} * E_{ij} * R_{ij} \quad (3)$$

Where:

$i = 1; 2; \dots; n$ (row)
$j = 1; 2; \dots; m$ (column)

Number of columns is defined by the volume of tasks (T)
S_i ... is stage
PN_i ... is the volume of parts that the stage contains

$$PN = \{PN_1;\ PN_2;\ PN_3; \dots PN_n\} \quad (4)$$

T_C ... is a technical complexity
E ... is the error rate
R ... indicates risk (risk)

4. Summary

According to connection of Industry 4.0 to engineering environment, it is necessary to stay productive, flexible and with appropriate quality. Also, according to globalization and competitive market, it is necessary to be fast, cheap and accurate enough for satisfaction and passion of our customer. This leads to a progressive way in planning and usage of some elements of modern cost methods such as TC and LCC. These methods can bring to engineering different view on whole environment and more of the above-mentioned elements such as cost saving, productivity, quality and even better relationship with customer. This tool is in process of testing and after this period, it can bring to us better view on this environment and possibly other issues to solve.

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Abbreviations list

BOM	Bill of Material
E	Error rate (%)
LCC	Life-Cycle Costing
PN_{ij}	Part Number (quantity)
P_J	Project
P_i	Product (quantity)
R	Risk (%)
S_i	Stage (quantity)
T	Task (quantity)
TC	Target Costing
T_C	Technical Complexity (%)

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