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EFFORT ESTIMATION IN QUOTATION PHASE OF COMPLEX PROJECTS DEVELOPMENT

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***Abstract*—**In this paper the aim is to define and explain a quotation phase (estimation of effort and costs), for complex development projects (mechanical, hardware and software development), based on project classifications. One of the most important activities that are carried out on the project is the quotation phase. After receiving a Request for Quotation, the estimation of effort and cost and also the profitability calculation for the new project is needed. Both, under and over estimation of the project, may cause losses for the business. Due to carry over of the projects, action requested by the customers, quotation is not precisely done. By introducing the project standardizations, based on the level of novelty, the estimation of cost and effort can be improved.

***Keywords*—**Project profitability, effort estimation, cost, quotation phase.

I. INTRODUCTION

ACTUAL trend in automotive component industry is that the product which has to be developed, uses another similar product as start point. When a new product has to be developed, the related project created in the company, goes through several phases.

One of the most important phases of a project is the quotation phase; the estimation of cost and effort for that project is done. Quotation term is defined by Project Management Institute as ”terms such as bid, tender, or quotation are generally used when the seller selection decision will be based on price (as when buying commercial or standard items” [1].

International VDA (Verband der Automobilindustrie) standard explains that ”the estimation is necessary in order to be able to make the financial resources available for the subsequent project phases.

It must become clear, that the achievement of the reliability targets, involves costs that must be stated and considered in the budget planning at an early stage” [2].

The project is defined as:

1) ”A specific approach that allows methodical and progressive structuring of one following reality; it is defined and implemented to respond the need of a user, a client or clients, involving a goal and actions that will be undertaken with specific resources” [3];

2) ”A temporary effort and unique with a start and end date, which will create a product, a service or a result” [4];

3) “A unique process, consisting of a set of coordinated and controlled activities, with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including constraints of time, costs and resources” [5].

The project contains a set of specific activities that can be characterized, as more often by: definition, needs, clear and measurable targets of quality, cost and time, limited resources, high level of novelty and high or moderate uncertainty.

A project activity shall be the intellectual or physical action, with dates of beginning and end, with a defined budget and targets in order to give an expected result.

In [6], the specific activities are ”necessary to complete the project and produce all of the project deliverables”.

Scope, time and cost are evaluated on the project, using quantitative metrics. The project strategy is assessed using qualitative metrics.

The end of the Pahl and Beitz study in Engineering Design, shows the need for development procedures of cost estimation, ”the following aspects have been criticized by industry: procedures for estimating costs are insufficiently developed” [7].

After identification of the need, Fig.1, the customer sends a Request for Quotation to the supplier, which will give a price for development. The project development will start based on needs identified by the customer on the market. “Source of design and development task is a direct request from a known client” [7].

After the company is nominated to participate to the quotation (development/production effort and cost estimation), a team is nominated in order to estimate the development / production effort and cost of all activities. Effort estimation (project quotation) is done at the end of need analyzing phase and at the beginning of concept phase, according to the “lifecycle phases of the product”

[3]. The objectives in this phase are: reduction of launch time for production, development forecast of cost and product performances" [3].

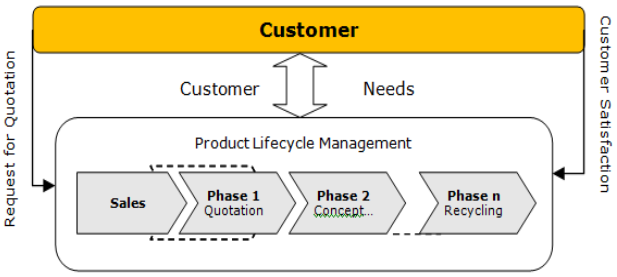

Fig. 1. "Product lifecycle" [3].

"Estimation should be made by practicing some good predefined method" [8]. According to [9] "an estimate is a realistic assessment based upon known facts about the work, required resources, constraints, and the environment, derived from estimating methods, whereas a target or goal is a desired outcome, commitment, or promise".

The next step is to define a quotation procedure (cost estimating and customer specification assessment), for complex development projects (hardware, mechanical design, software), based on re-used activities and project classifications.

II. Concept Methodology

A. Systematic design and cost estimate on the project

A systematic model "uses concept catalogs, but does not say how to choose the best solution" [3]. There are several fundamental concept models. The most known, are initial concept and re-concept.

Initial concept – "is performed for the first time, without existent references or past experience, which would allow the inspiration for copy, re-conception or solution improvement" [3]. That means, it is applied to a new development project, which will use a new technology unknown at that time.

Re-conception – or "conception improvement of an existent product, based on customer requirements, aiming architecture optimization, costs, weights, volumes, performances, taking into account competitive products and past experience" [3].

The aims of systematic concept are "activities management, cost management, quality management and planning management" [3], what makes that the estimation cost in an early phase of the project is essential and should be done with precision due to the impact, which can be in the project development lifecycle.

B. Axiomatic concept and cost estimation

Axiomatic model "helps the creative process and allows the identification of best solutions from a multitude of all solutions" [3], fundamental axiomatic model "switches from WHAT domain (what we want to obtain) to the HOW domain (how we plan to achieve the targets)" [3].

The constraint cost must be set as target and measurement indicators have to be defined, starting in quotation phase.

III. Project Classification in Quotation Phase

Actual trend of product development for carmakers is the development of the products based on module or platform projects. This means that a project module is developed for a segment of products; product variants are derived from there. In this case, the quotation for activities must be more precisely done.

The resulted product will be much cheaper due to this reusing of activities.

The use of multiple variants of the products raises the need to standardize project types. Each project should follow an own process with specific activities, part of a global development process.

In order to fulfill this customer trends for standardization, Fig. 2 present three types of development projects.

Effort estimation is done hardly, due to adapting activities from one project to another.

"Cost estimation imply development of a quantitative assessment of the result" [10] and in the guideline of Project Management Institute is explained that the "costs are estimated for all resources that are applied to the activity cost estimate.

This includes, but not limited to, direct labor, materials, equipment, services, facilities, information technology, "exchange rates, or cost contingency reserve. Indirect costs, if they are included in the project estimate, can be included at the activity level or at higher levels" [1].

For a more efficient mapping of the project quotation needs of the customer, the following data should be known about the project:

1) Project type:

a) Project as a new generation for the product segment;

b) Project as same generation, but other variant of product;

c) Project as a module;

2) Complexity of product:

a) Simple project – mechanical development only; small changes of a current existing design;

b) Semi-complex project – mechanical design and hardware design development; projects are a previous generation / experience exist but still are challenging tasks in terms of technical / timing timeframe; only part of the involved disciplines are challenged (e.g. Mechanical Design or Hardware);

c) Complex project – mechanical, hardware and software development; projects were complete new product

platforms are developed or all disciplines are challenged to find implement and validate new development items.

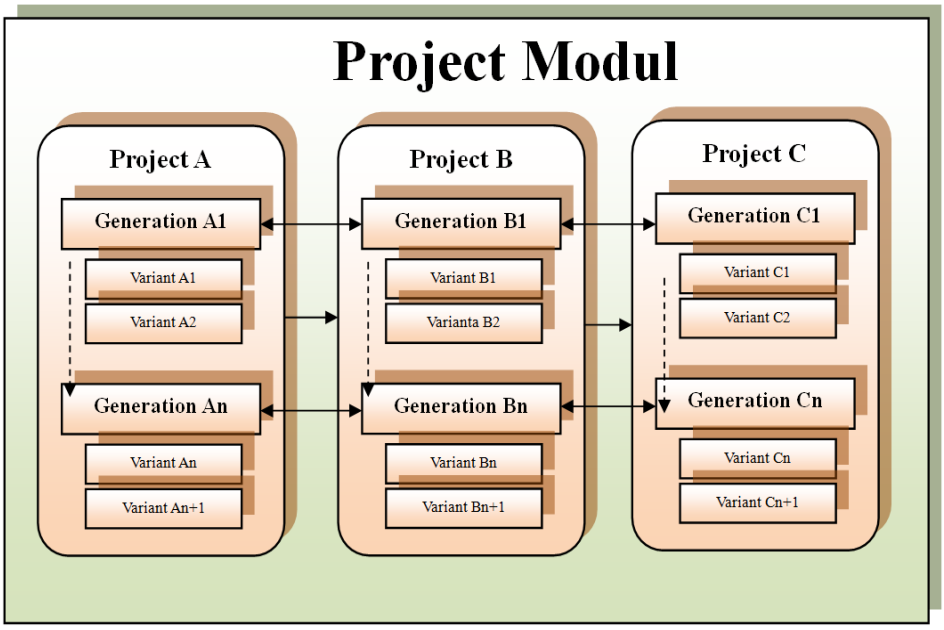

Fig. 2. Project types

All this standardization of project types is done in order to minimize costs and to reduce development time. ”To reduce development effort, approaches for developing, size ranges and modular systems are introduced. The methods for quality assurance and cost estimation help increase customer satisfaction and improve market competitiveness” [7].

Moreover, the costs have to be estimated for each discipline, which will participate on product development.

The project costs can be ”expressed in monetary units or work hours” [10].

In [1] the estimate activity duration is described as ”process of estimating the number of work periods needed to complete individual activities with estimated resources”.

A. Project type A with HIGH level of novelty

A project type A comes into quotation phase when: it is a new product in the market, it uses an advance development technology, there could be high development risks, and it could be a critical customer (important customer with very strict requirements).

For this type of product quote does not exist a history in order to get easier effort estimation for all activities (e.g. component development for cars that use hydrogen instead of gasoline).

Pahl and Beitz describe these products as ”new tasks that are realized by original designs incorporate new solution principles.

These can be realized either by selecting and combining know principles and technology, or by inventing completely new technology” [7].

Another term which characterize this type of projects is design originality, shown by Pahl and Beitz, ”Original designs usually proceed through all design phases, depend on physical and process fundamentals and require a careful technical and economic analysis of the task. Original designs can involve the whole product or just assemblies or components” [7]. This means that the product goes through all phases presented in Fig. 1.

The experts and the quotation team will analyze each specific and standard requirement and will estimate all activities necessary to develop the product.

The project with high level of novelty has a high level of uncertainty and is recommended by Heerkens ”to understand exactly how to synthesize all of the uncertainties” [11].

The advantages for developing these projects are:

1) Usually they have a high budget for the development which can generate also a higher profit;
2) They will bring knowledge due to developing new technology;
3) Attract new customers for the same product.

The disadvantages for developing these projects are:

1) Risk not to achieve the quality, cost and time targets;
2) In case of unsuccessful, the company image could be affected; losing customers can be the consequence.

The effort estimation for projects with high level of novelty is carried out according to Fig. 3.

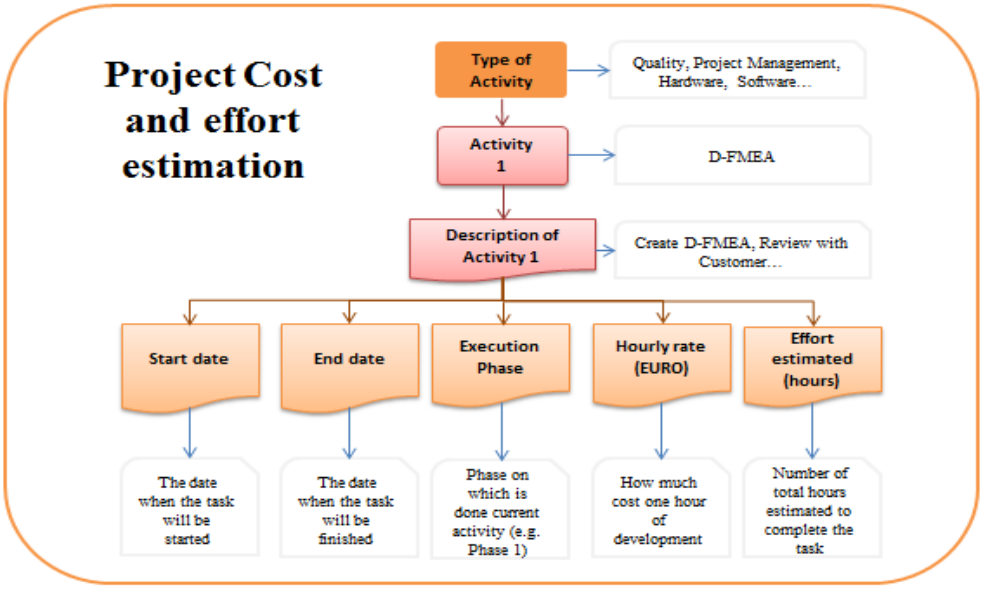

Fig. 3. Project cost and effort estimation

In this phase, the effort has to be estimated based only on the Request for Quotation internal (company management) or external (customer) and there is no history in estimation from other products and no reuse of activities are taken into account. For high complexity projects, a customer will not be attracted from the beginning of the project.

Basically, the quotation with customer starts after proof of concept is done, therefore is better to mark internal or external customer.

Development costs for this type of projects are high; an example of activities is shown in Fig. 4.

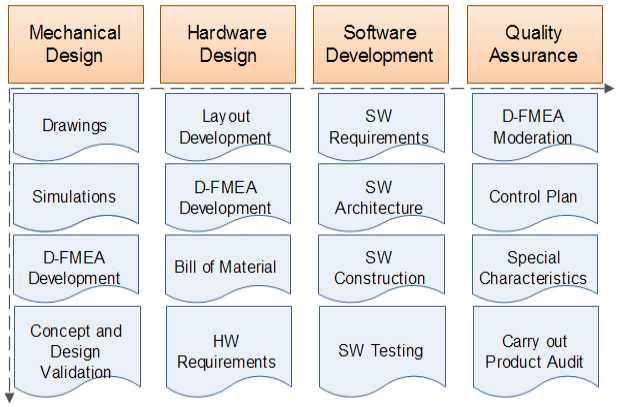

Fig. 4. Example of activities for project with high level of novelty, **A-type** project.

The activity costs are estimated by adding up all estimated hours for each disciplines in part and multiplied with the hourly rate, as is shown in Fig. 5.

Fig. 5. Cost calculation for projects with HIGH level of novelty

B. Project type B with MEDIUM level of novelty

The product to which we refer belongs to a new generation, than the product that already is in the development phase (same product runs in production or in development). The analyzed risks are lower and also the budget is lower than for the **A-type** project.

The base for developing this project is another existent project of past generation for the same customer and some activities are reused (activities are separately quoted for documentation updating, part number changing, etc.).

"In adaptive design, one keeps to known and established solution and principles and adapts the embodiment to change requirements. It may be necessary to undertake original design of individual assemblies or components. In this type of design the emphasis is done geometrical (strength, stiffness, etc.), production and material issues" [7].

The new activities are quoted in dependency with the novelty level; the estimation for new and reused activities is done according Fig. 3. An example of activities quoted for these types of project is shown in Fig. 6.

The activity costs are done by gathering all estimated hours for each discipline, in which are included also activities for adjustments or updates and multiplied with the hourly rate (Fig. 7).

The estimated effort will be different from the one in projects with high level of novelty, because:

1) Customer require to reuse some modules from a previous generation – the cost has to be just resumed on adapting the documentation, etc.;

2) Only improvements on the existing generation have to be done for the new generation – the costs for new change requests have to be estimated;

3) The project team has experience in developing this

kind of projects and a more accurate estimation can be done.

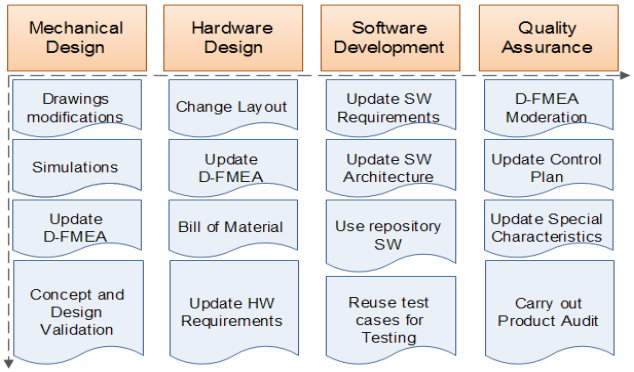

Fig. 6. Example of activities for project with medium level of novelty, **B** project

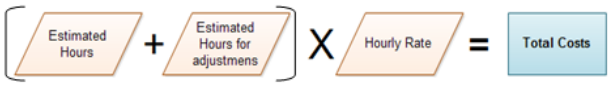

Fig. 7. Cost calculation for projects for MEDIUM level of novelty

C. *Project type C with LOW level of novelty*

The development for this project type is based on a product having the same generation and could be a variant for the existing product (e.g., product is assembled on a car with facelift).

"In variant design, the size and arrangements of parts and assemblies are varied within limits set by previously designed product structures. Variant design requires original design effort only once and does not present significant design problems for a particular order. It includes design within only the dimensions of individual parts are changed to meet a specific task. In this type of design is referred to as principle design or design with fixed principle" [7]. The projects have a low degree of novelty; they are small projects that do not have proper development. Most of these projects are changes on existing products (software, mechanical or hardware).

In addition, projects that contain modifications of other projects after Start of Production (cost reduction) are here referred. An example of activities quoted for these types of project is shown in Fig. 8. The new activities, which appear on C-type projects, are often parameter changes or small modifications of design. Cost calculation is done by multiplied estimated hours for adjustments on each discipline with hourly rate (Fig. 9).

The C-type projects are many, because most of the developed parts are "carry over" components. These parts have a solid base on the existent product on the market.

IV. Project Costs Estimation

In the quotation phase, the activities estimated as development costs, should be made accurate in order to deliver competitive data. A quotation form, should contain a base quotation and technical quotation.

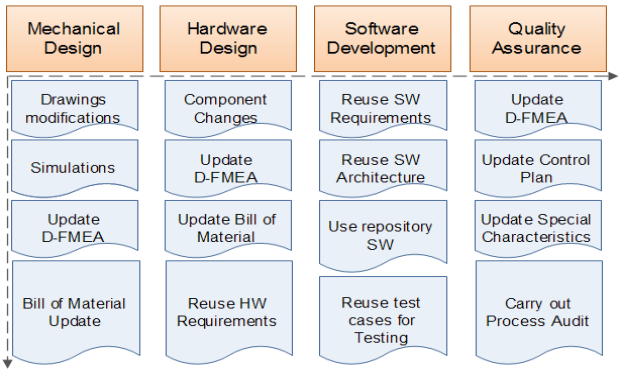

Fig. 8. Example of activities for project with low level of novelty, **C** project

Fig. 9. Cost calculation for projects with LOW level of novelty

A. *Quotation management*

After receiving the Request for Quotation some information's have to be known: a project name, project type, functionalities of the product, what activities are estimated for development.

Base activities have to be analyzed during quotation phase. These are:

1) Project yield – comparing the project development costs roughly with a similar project in development or in production and analyze the cost differences;
2) Feasibility study – analyzing if the product can be developed following customers specification and if the product is feasible in terms of technical and economical requirements;
3) Profitability calculation for product lifecycle;
4) Planning and calculation of the initial development cost for samples (sample A, B, C);
5) Assessing ASPICE level required (Automotive Software Process Improvement dEtermination);

B. *Project profitability calculation*

The goal of the quoted project is to be profitable for the organization. Profitability is the consideration of all cost relevant position, sales price and volumes over product lifecycle and is a financial evaluation of the project.

One of the key elements of the profitability calculation is the sales price, which is the price for the customer quotation given by sales.

Another key element in profitability calculation is risk assessment shown by Juran that "a key to profitability is accurate risk assessment". This means that "some level of risk is always associated with profitability, irrespective of the product, service, or the industry which offers them; in financial services the risk is the more

apparent because the product itself directly involves money" [12].

Methodology used for profitability calculation is shown in Fig. 10.

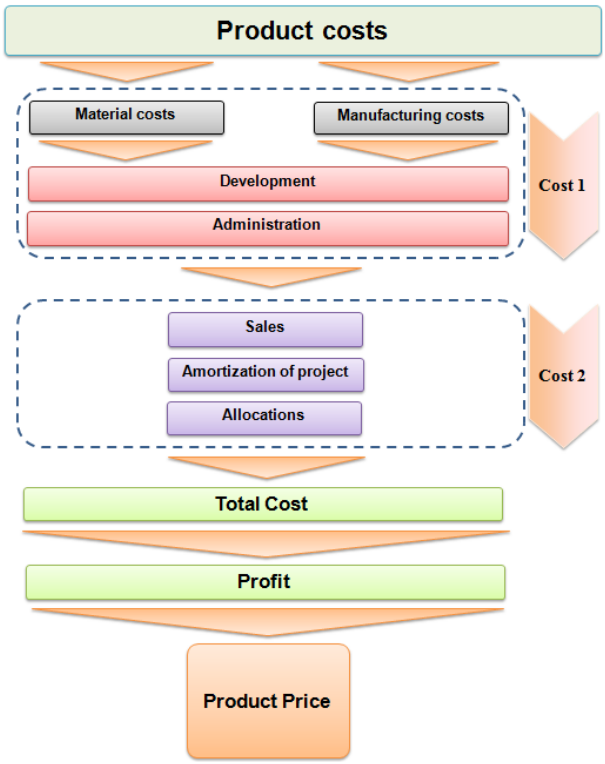

Fig. 10. Project profitability

C. Technical quotation

Based on the Request for Quotation is the development time plan defined. Usually these delivery dates are received from the customer.

Internally the dates from the customer are checked with in order not to overlap the activities and deliveries to the same customer.

Delivery dates are mostly planned along the development project lifecycle and will be moved just in case of customer request.

If it's needed, based on customer planned dates, especially if the supplier is the second tier and the project is complex,(SW development) new dates can be created, with a more earlier delivery date than the customers required delivery date.

Standard costs are the costs for each discipline in product development do not depend on subsequent changes on the project and are agreed with the customer for each phase of development or production.

Costs estimation is done according to project classification of degree of novelty.

Other standard costs included in development are costs for standard roles like activities done by: project manager, software project manager, software quality engineer, test manager, etc. Each role has a standard estimation for activities.

In of the technical quotation is also the effort for recurring activities estimated, like: team meetings, reporting (at project management level and higher level), preparing of audits, preparing of meetings with customer (FMEA review with customer), business trips, etc.

Change requests estimation during development – in case of new changes, requested by the customer, a re-estimations has to be taken into consideration. Some topics have to be considered, like identification of work products, estimating activity duration (the costs, amount of time for new development, support activities, etc). In case of new change requests raised by customer, a structured and traceable planning for processing new activities has to be created.

V. Conclusion

In this study, the methodology of estimating effort and costs, in quotation phase for projects development is defined and explained.

The used methodology for quotation phase is done according standardization of project types, based on project's novelty level.

The projects are standardized in three types: project of type A with HIGH level of novelty, project of type B with MEDIUM level of novelty and project of type C with LOW level of novelty.

The perspective of this study is to show how the estimation of effort and costs could affect the quality and maturity of the project and how risk assessment can be done more accurate in order to secure project profitability over project lifecycle.

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