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Identification of Profitable Areas to Apply Product Configuration Systems in Engineering-To-Order Companies

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Abstract. This article suggests a systematic framework for identifying potential areas, where Engineering-To-Order (ETO) companies may increase their profitability by implementing a Product Configuration System (PCS). In order to do so a three-step framework is proposed based on literature. The starting point is to conduct a profitability analysis to determine the accuracy of the cost estimations, and based on that the reason for the deviations across different projects is found. The next step is to generate the scope for different scenarios that aim to improve the current situation. Finally, it is suggested to make a cost-benefit analysis for different scenarios to determine where a PCS can provide the most benefits. This article is supplemented with a case study from an ETO company where potential areas for using PCS were found by applying the suggested framework.

Keywords: Product configuration system (PCS); Profitability analysis; Engineering-To-Order (ETO) companies

1 Introduction

Engineering-To-Order (ETO) companies are increasingly showing more interest towards applying a Product Configuration System (PCS) in order to support their various specification processes. Specification processes can be defined as a business processes where the customer's requirement are analysed and the product is designed to fulfil the customer's needs [1]. PCSs can be defined as an IT system used in a design activity, where a set of components along with their connections are pre-defined and additional constrains are used to prevent illegal combinations and to reduce the solution space [2].

ETO companies that have implemented a PCS have achieved substantial benefits in terms of shorter lead-time, improved quality of products and specifications, more on time deliveries, reduced resource consumption, optimization of product and increased customer satisfaction [3], [1]. Furthermore, utilizing PCSs provides ETO companies with the opportunity to increase sales of more standardized products and become more in control of their product range. This can result in higher efficiency and improved quality [4]. In ETO companies PCSs are usually gradually implemented where they are normally used to only support a specific part of the specification process or a subset of the product families. That is sine it requires significant work to acquire and structure the product information that are needed to be modelled in to the PCS due to the complexity of products and the specification processes. Therefore it may not be profitable to formalize the complete product knowledge, especially if the sales volumes are low [4].

When starting PCSs projects in ETO companies, there are currently no existing guidelines supporting the decision making processes regarding how to identify both the products and the specification processes. In order to improve the decision making process this article proposes a three step systematic framework to identify the most profitable areas for applying a PCS in ETO companies. The first step is to analyse projects in terms of profitability and accuracy of the cost estimations in order to identify the factors causing the deviations from estimated to realized cost. The second step is concerned with identifying different areas for applying a PCS and the scope of the system, and finally in the third step cost-benefit analyses are conducted in order to find the most promising scenario and areas for applying PCS. The article's aim is to provide answer to how to identify profitable areas to apply PCSs in ETO companies bases on the following questions:

1. How to analyse profitability and accuracy of cost estimations in ETO companies?
2. How to identify possible areas where PCS could provide cost savings for businesses?
3. How to assess cost-benefits for potential applications of PCS?

2 Research method

The research methodology in this paper is structured in two phases. The *first phase* is dedicated to the development of the framework, which is based on both literature and experience from working with PCSs in ETO companies. The *second phase* is concerned with the testing of the framework. For that purpose a project team was formed in an industrial ETO company operating in the oil and gas industry, including two researchers from the Technical University of Denmark and experts from the company. During the period of the case study weekly meetings were held to validate the processes of the project, access to internal data bases was provided and workshop with key employees were held. Aligned with the data collection part, direct method of interviewing with the users of the framework combining with the researchers' observations is considered.

Finally, in order to identify the potential cost of developing and implementing a PCS, seven ETO companies that had implemented a similar system where contacted and asked to provide information regarding the development and maintenance of their PCSs.

3 Literature review

In order to examine the theoretical background of this research a literature review was conduct in the area of cost analysis in ETO companies and ETO companies that have implemented a PCS. The main purpose with the literature review was to gain insight into the different approaches used to analyse cost in ETO companies and to identify how ETO companies have implemented PCS with regards to scope of products, processes and cost-benefits.

3.1 Cost Analysis in ETO Companies

ETO companies providing customized products face the challenge of reaching an acceptable earning before interests and taxes (EBIT) and to achieve the same gross margins from different projects [5]. In the sales phase the most important decisions regarding profitability of projects are taken and where inaccuracy in the cost estimations can have significant consequences. By overestimating the cost the risk of losing the customer increases and by underestimating the cost project's profitability is reduced. In the pre-tender phase inaccuracy of the cost estimation is often the result of being made within a limited time and when the project scope has not been fully determined [6]. Other factors that can influence the cost estimations are project complexity, technological requirements, project information, project team requirement, contractual arrangement, project duration and market requirements [7].

Several approaches have been developed to estimate the cost in companies. Cooper and Kaplan [8] proposed Activity Based Costing (ABC), which has been proven to be a powerful tool to distribute the overhead cost by first distributing the indirect cost evenly to the various activities performed by the company's resources. Thereafter, the cost is assigned to individual orders, customer or products. Walker et al. [9] suggest a Volume-Based Costing and Feature Costing method in order to allocate cost on product's attribute level. Kaplan & Anderson [10] propose a Time-Driven ABC, approach where resources are connected directly to cost objects and where time estimations are used to predict the cost for certain activities. Zhang and Tseng [11] then define a method for assessing products' profitability and cost behaviour from four aspects in order to provide a method for measuring product costs in terms of: unit level, batch-level, product-sustaining and facility-sustaining.

3.2 Analysis of ETO Companies That Have Implemented a PCS

Several examples can be found in the literature of companies providing customized products that utilize a PCS. This section provides description of processes and products that are included in PCSs followed by cost / benefits from the implementation.

Barker et al. [12] present the case of Digital Equipment Corporation. The PCSs were developed to check the technical correctness, to guide the assembly of customer's order, select part that can be purchased, illustrate the computer room under design and finally to configure clusters. The PCSs systems have been gradually implemented to support the complete product range, which consist of 42 product families. Main benefits are described in terms of improved quality, optimized performance of the products, increased manufacturing flexibility and increased product development. The development took place over nearly 10 years and the estimated yearly net return is expected to be around $ 40 million.

Fleischanderl et al. [13] present a PCS for complex telephone switching systems. The general configuration task involves selecting the right components, connecting them together and setting the different parameters. The system supports various functions of the company and the product life cycle, such as sales, engineering, manufacturing, assembly and maintenance. The benefits from the implementation of the PCS are improved quality, identification of errors and increased knowledge sharing. The development time or the cost is not indicated. However, a positive return of investment was achieved in the first year of operation.

Forza & Salvador [4] present a case of company making voltage transformers where a PCS is used to support the information exchange in the sales phase, the data gathering and to ensure validity of the configuration. The technical features are only included in the system for the simplest product family. For the more complex product families, the system supports the design activity by collecting the technical characteristics. The main benefits are listed in terms of reduction in errors, lead-time and resources. Furthermore, the correctness of the bill of material generated by the PCS has positively impacted the production. For the development of the system it is mentioned that that building up the product model was a very time consuming activity.

Hvam [14] describes how PCS is used to support complex engineering processes in the sales phase by automating the quotation generation for a cement plant. In the first prototype of the system the focus was set on 20% of the parts, which generate 80% of the cost. The main benefits are described in terms of reduction in lead time for generating tenders and engineering hours for the conceptual design, increased quality of the quotation and optimization of the plant. Furthermore, the company might gain extra sale of cement plant as a result of shorter lead time, which would outsource all other benefits [1]. The development of the quotation processes has lasted for 3-4 years and one year was spent on generating the PCS for proof-of-concept. The development cost of the system was estimated to be € 800.000.

Petersen [15] explains how PCS was used to support the sales and engineering process at Aalborg Industries A/S, which produces marine boiler for ships. The PCS was gradually implemented where one to two product families was added at each time. The system is used to support the sales processes. The realized benefits are listed in terms of reduced lead-time and resource consumption for making the quotations. The development of the system included evaluation of different systems, standardisation of the product programme and implementation of the product knowledge into the selected system.

4 The Suggested Framework for Identification of Profitable Areas for Applying PCSs

As revealed in the literature study ETO companies commonly gradually implement PCS to support specific parts of their products range and specification processes. In order to improve the decision making processes regarding how to select the products and to what extended the system should support the specification processes, a three step framework is proposed where profitable areas can be identified in ETO companies for applying a PCS. The individual steps and sub steps of the framework are shown in Figure 1.

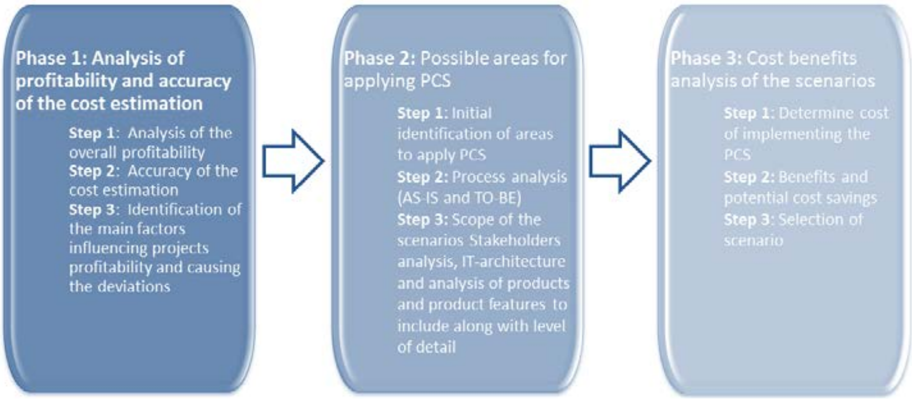

Fig. 1. Framework for identifying profitable areas for applying PCS in ETO companies

Phase 1: Analysis of Profitability and Accuracy of Cost Estimation

The first phase includes analyses of the projects profitability and of the accuracy of the cost estimations. Based on those analyses the main factors influencing projects profitability and causing the deviations can be identified. To calculate the profitability of the projects it is suggested to use contribution margins (CM) and contribution ratios (CR). The CM (1) and CR (2) are calculated as following [16]:

$$CM = Sales\ price - cost\ price \tag{1}$$

$$CR = \frac{CM}{Sales\ price} \tag{2}$$

When calculating the cost price it has to be ensured that the right approach is used. The most common approaches include material and production cost to determine the cost prices [17]. Other factors that might be added to the cost estimations are labour, machinery and inventory cost [11]. As the fixed cost is not included in the CM, the margins have to be high enough to cover that cost.

In order to analyse the accuracy of the cost estimation it is suggested to compare the CM and CR from what is expected based on the budgetary offers to the actual CM and CR calculated after the project has been closed. Based on those analyses the main factors that cause deviation from the estimated cost to the realized cost can be identified in more details.

4.1 Phase 2: Possible Areas for Applying PCS and Scope of the System

The second phase includes an initial identification of potential areas to apply PCS based on the findings in the first phase. Thereafter, process analysis are conducted where the current processes (AS-IS) are analysed and the future processes are developed (TO-BE), which includes where to apply a PCS to increase the efficiency of the process. In order to map the processes different techniques can be used. Business Processes Modelling Notation (BPMN) has proven to be useful for this purpose to demonstrate the communication between different actors and the tasks performed by the individual actors [18]. Finally, the scope of the different scenarios is analysed in terms of stakeholders, IT-architecture and products and products features to include along with level of details [19].

4.2 Phase 3: Cost-Benefit Analysis of the Scenarios

In order to estimate whether a company should proceed and invest in the PCS it is recommended to do cost-benefit analysis. Cost-benefit analyses are carried out to compare different scenarios and are an effective method to compare different results from variety of actions [20]. When estimating the cost of developing a PCS several factors have to be taken into consideration such as; expected time needed from internal and external resources in order to increase standardization of the product range as well as to gather and structure the product information and to model them into the system. Based on this analysis, the company should be able to make informed decision regarding whether it provides value for the business to implement a PCS. Furthermore, in order to keep the level of comitment from the top level managenet, economic benefits have to be made very clear from the beginning of the project and empahized in order to keep the project alive [21].

5 Case study

The framework was tested in a global engineering company that provides equipment as well as complete systems and services for the oil and gas industry. Over the last years the company has gone through significant growth that has resulted in greater product variety and higher processes complexity, which has negatively affected the profitability of the company.

The data for the analysis was gathered from the company's internal systems and verified with the company's employees. It was decided to analyse both projects where a complete system solution for rigs is provided and smaller projects where single equipment is sold, as it represent the main activities at the company. The complete system projects require highly complex solution that has to be adjusted to the customer's demands and includes; engineering work, manufacturing and commissioning at the customer's site. For the single equipment sale commissioning is not required. The lead-time for complete system projects is approximately four years. Therefore, to be able to include both pre- and post-calculations for the projects the time scope for the analysis was set to four years. This resulted in 116 single equipment projects and 12 complete systems projects. The complete systems projects were divided into three categories with regards to rigs types, which will be referred as types A, B and C. For the smaller projects it was decided to not make any categorizations.

5.1 Phase 1 - Analysis of Profitability and Accuracy of the Cost Estimation

Step 1: Analysis of overall profitability. The first step includes analysis of the projects' profitability both for the complete systems and the single equipment projects.

The cost used for the calculations of the CM consists of engineering hours, production cost and material consumption and commissioning.

The calculations of the company's overall projects' CM indicated great deviation between the budgetary offers and the actual margins, calculated after the project had been closed. This deviation caused the company € 101.304 million reduction in CM from what was expected, resulting in CR of only 0.65% instead of 21.74% for the complete system projects. For single equipment projects the analysis indicated much less deviation and more profitable business, even though it only accounts for 12% of the total revenues.

Table 1. Overview of the company's profitability

	Complete systems projects			Single equipment sales projects		
	Actual	Budget	**Deviation**	Actual	Budget	**Deviation**
Revenue	€ 542.976 million	€ 482.160 million	**€ 60.816 million**	€ 74.424 million	€66.192 million	**€ 8.232 million**
Cost	€ 539.448 million	€ 377.328 million	**€ 162.120 million**	€ 48.384 million	€44.352 million	**€ 4.032 million**
CM	€ 3.528 million	€ 104.832 million	**€ -101.304 million**	€ 26.040 million	€21.840 million	**€ 4.200 million**
CR (%)	0.65%	21.74%	**-21.09%**	34.99%	32.99%	**2.00%**

Step 2: Accuracy of the cost estimations. In order to calculate the accuracy of the cost estimations, the actual CM and the CR are compared to the expected ones in the budgetary offers.

The analysis for the *complete system projects* revealed that in 11 out of 12 projects, the actual profit is much less than what was expected in the budgetary offers (Figure 3). However, as previously stated there is a great similarity between projects that are carried out in the same categorizes (A, B and C). Therefore as the pattern in Figure 2 shows, due to economies of scope the CM is expected to increase after completing the first project. Nevertheless, the cost reduction is not in proportion to the amount of information that can be reused, which can partly be explained by the fact that incomplete project were copied as they were overlapping in time.

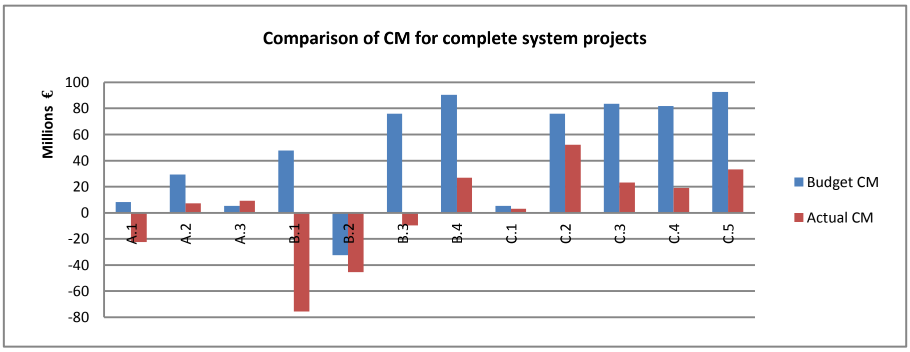

Fig. 2. Comparison of CM in the budgetary offers and the actual for complete system projects

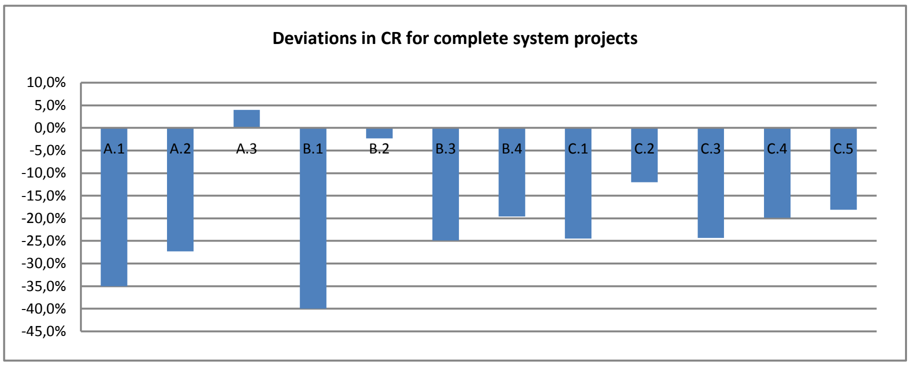

Fig. 3. Deviations in CR for complete system projects

For *single equipment projects* the analysis revealed also great deviation between the expected CM in the budgetary offered and the actual CM (Figure 4) as well as for the CR (Figure 5). However, the deviation fluctuates both on the positive and the negative side and the results does therefore not affect the overall profitability. This indicates that the cost estimation is not accurate as the cost is both over- and underestimated. Even though the overestimated cost results in higher CM the risk of losing the sale increases as the customer might go elsewhere to purchase the equipment. In today's market condition this is not a problem due to strong market position of the company. However, it is anticipated that the competition on the market will increase and therefore this could become a threat in the future.

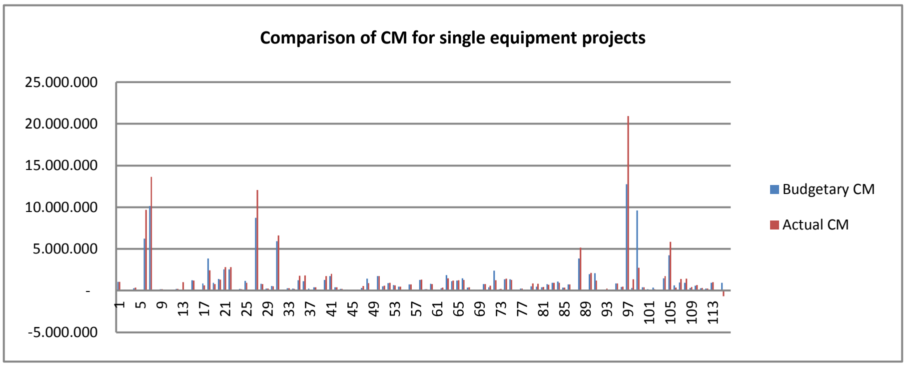

Fig. 4. Comparison of CM in the budgetary offers and the actual for single equipment projects

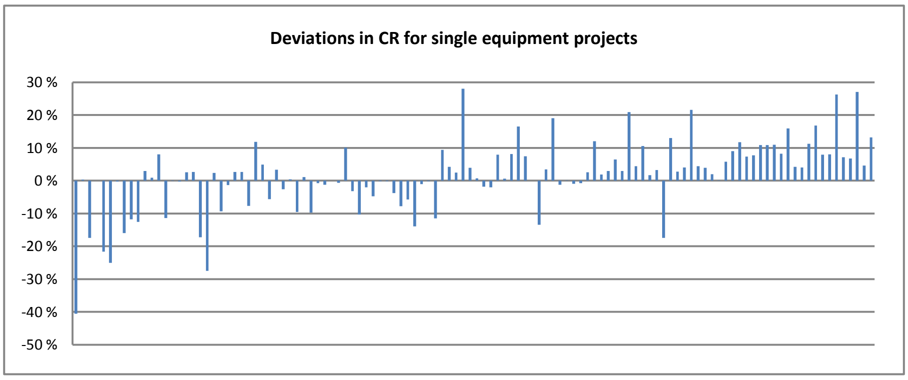

Fig. 5. Deviations in CR for single equipment projects

Step 3: Identification of the main factors that influence the projects profitability and causing the deviations. In order to identify the main factors, a brainstorming session was carried out at the company with representatives from the management, project leaders and other key employees. The most important factors identified are listed below.

- *External factors:* The time scope of the project has great impact on their profitability. It was calculated that the external factors were accountable for 40% of the deviations in the CM. From these 40%; 15% could be traced to increased steel price, 12% to increased cost of industrial products and 13% to increased cost of labour (engineering, manufacturing).
- *Cost of carry over work:* The cost of carry over work was extracted from the company's internal system and accounted for 3% of the reduction in the CM for the projects. The carry over work occurs when additional work has to be made at the customer's side as result of defects or other unforeseen factors, which fall under the company's warranty.
- *Workflow and responsibility:* There is unclear workflow and lacking overall responsibility when it comes to the purchase, engineering, production and commissioning. Furthermore, the knowledge transfer between different departments is lacking.
- *Incompleteness or errors in the product's specifications:* Lack of information in the sales phase has resulted in delays and costly changes late in the processes. Furthermore, this also has impact on the production, commissioning and the carry over work when defects in the products have to be fixed.
- *Tendency to sell products not within the company's standard product architecture*: Number of sales persons has grown significantly over the last year and only the most experience sales persons have the overview of the standard solution and how they can be combined. This has resulted in costly development of new product that the customer cannot be charged for as it was thought to be within the company's standard product range.

- *Product designs:* The focus of the company has been on designing products for specific projects instead of designing the products and adjusting them to different projects. Therefore, product growth is not in control. Furthermore, the master data often contains errors and standard interfaces are not defined.

5.2 Phase 2: Possible Areas for Applying PCS

Step 1: Initial identification of areas to apply PCS. The analysis from the first phase indicates that many of company's current challenges are concerned with the early phases of the sales and engineering processes for both projects and single equipment sale. In the early stages of the sales and engineering processes the most important decisions regarding products capability and 80-90% of the products cost are determined [1], [22]. Therefore, two scenarios are generated in order to determine the scope of the PCS, for both complete system projects and single equipment projects where PCS is used in the early phases of the specification processes.

Step 2: Process analysis. The most important specification processes in the early sales and engineering phase are regarding; the encapsulation of the customers' demands, the transformation of the customer's demand into valid solution that can be provided by the company and finally the ability to make cost estimation. In Figure 6 the current (AS-IS) process flow is visualized where the most critical aspects are marked with blue colour and the future (TO-BE) processes where the processes are supported with PCS. In the TO-BE processes, the PCS is used by the sales persons where the system should ensure that all relevant information is gathered. For standard products the system should be able to suggested feasible solution while for none standard products an input from engineer is required before completing the budgetary offer.

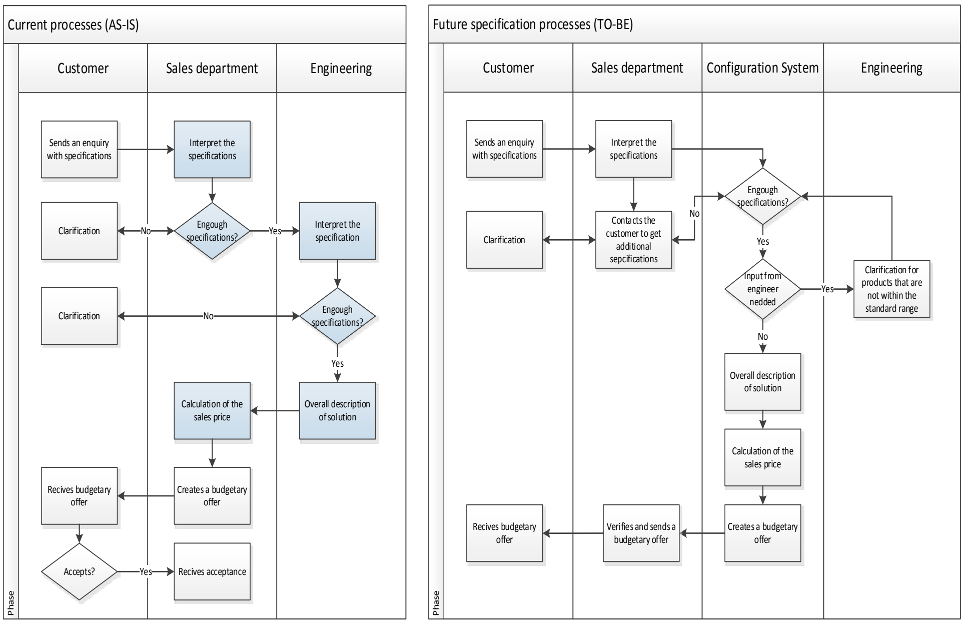

Fig. 6 AS-IS and TO-BE process flow for producing a budgetary proposal both for complete system projects and single equipment projects

Step 3: Scope of the Scenarios. The individual step in this phase builds on framework for scoping product configuration project for ETO companies as suggested by Shafiee et al. [19].

Stakeholder analysis. The main stakeholders that have been identified are employees from sales and engineering. The sales employees are the main user of the system and the engineers have to provide the information and work on standardization of the product range. The management is also important as they have to support the project and finally employees involved in the manufacturing and commissioning will be affected as they will be working with the product specifications and more standardised product range. Those stakeholders' requirements have to be taken into consideration. Tools such are use case diagrams are used to communicate and determine the stakeholders' requirements [19].

The overall content of the PCS. The overall content of the PCS is described by the main IT-architecture, input/outputs, main functionalities and integrations. In this case it was decided to only include the main functionalities, the input/output and integrations to describe the overall content of the system. The requirements for each of those categories are shown in Table 2 for projects and single equipment sale. The overall content of PCS is determined based on the stakeholders' requirements.

Table 2. Scope of the scenarios

Complete system projects	**Single equipment projects**
Inputs / outputs The main inputs to the system are concerned with regulations for different regions, space available for installation, required performance, environmental loads and temperature ranges. The main output from the system is a complete budgetary proposal including the calculations of cost, weight and power consumption, list of machines and the overall process flow. Main functionalities • Secure that all relevant information are gathered from the customer. • Capacity calculations with respect to oil power consumption and drilling speed. • Suggest an overall solution that fulfils the customer's requirements. • Visualize the drilling process and how a different selection affects the overall processes. • Ability to handle complex calculations as well as integration with other calculation systems. • Estimation of cost of engineering hours, material cost, fabrication and commissioning. • Generate budgetary offer. • Integrations with CAD systems to make the engineering diagram generation from PCS.	Inputs / outputs The main inputs to the system are based on the customers' requirements regarding performance parameters. The main output from the system is a complete budgetary proposal. Main functionalities • Secure that all relevant information are gathered from the customer. • Give an overview of different combination within the standard product architecture and suggest a solution that fulfils the customer's requirements. • Ability to overrule some of the default options with additional functionalities or additional performance. • Generate bill of material. • Estimation of cost of engineering hours, material cost and fabrication. • Generate budgetary offer.

Products and product features to include in the PCS and the level of details. In this phase a description of the products to be considered for implementation in to the system and their level of details should be provided. Identification of the right level of details when scoping the system is critical in order to reduce time and resources when developing the PCS [19]. The product features can be divided into property models, product structure models and other lifecycles models [1]. Furthermore, Hvam [14] describes how basic modules consisting of machines and equipment can be used to cover 80% of the overall specifications for PCSs of complex ETO products, such as a cement factory. The products and product features to include in the PCS and the level of details for the scenarios are shown in Table 3.

Table 3. The products and product features to include in the PCS and the level of details for the scenarios

Complete system projects	**Single equipment projects**
Products A complete system solution that is provided in a projects consist of 7 main processes units, where each unit consist of several machines that again consist of numbers of equipment. In general a com-	*Products* The single equipment can vary from equipment provided for machine or it can be a complete machine.

plete project consists of 40-80 machines that have to be combined and complex constrains regarding interfaces have to be taken into consideration. *Product features and level of details* Here the basic modules correspond to the 7 processes units. An example of a processes unit or basic module is trip out. Here the main focus is on the product properties and the product structure models on a rig level.	*Product features and level of details* Product features for the single equipment sales are modelled on machine level. An example of a machine for the trip out processes (that was described as one of the basic modules for project) is a crane. As for the projects the main focus is on product properties and products structure models in this case it is provided in more detail or on a machine level instead of a rig level as for the projects.

5.3 Phase 3 – Cost-Benefit Analysis for the Scenarios

In this phase a cost benefit analysis are used in order to identify the feasibility for implementing a PCS for the developed scenarios. Based on this analysis the most promising scenario can be chosen.

Cost of implementing PCS for the scenarios. The costs of implementing the PCS will require both internal and external resources to build up the required knowledge, to improve the product architecture and to model and gather information for the PCS. Furthermore, configuration software licenses have to be purchased for the users. In order to estimate the development and the maintenance cost seven ETO companies that have implemented a PCS were asked to provide information, which are summarized in Table 4.

Table 4 Development cost for PCS for ETO companies

Company size (no. of employees)	**Complexity of the PCS**		**No. of PCS**	**Development cost**	**Man-months used for development**	**Man-months used for maintenance**	
	Attributes	Constrains				Internal	External
>1000	2000	450	4	€ 923,470	30	24	0
>1000	2000	2001	10	€ 469,137	15	14	0.1
<500	999	499	1	€ 840,828	36	7.5	0
>1000	2001	499	4	€ 1,206,353	12	36	0
>1000	300	350	2	€ 133,145	16	9.6	0
<500	999	2000	1	€ 446,350	30	8	0
<500	2000	999	2	€ 1,072,314	12	6	1

Based on this it can be assumed that the development of a PCS in ETO companies is on the scale 133,145 € - 1,260,353 € (Table 4). Those numbers should only provide some rough indications of potential cost range as the projects scope and products complexity varies greatly between these cases.

The cost for the developed scenarios is estimated based on experiences from other projects, interviews with experts at the company and the suggested scope of the PCS. In Table 5 the cost estimation are listed for both the scenarios.

Table 5. Estimated cost of the PCS fort he developed scenarios

	Complete system projects				Single equipment projects			
	Development		Maintenance / year		Development		Maintenance / year	
	Man-months	Cost (€)	Man-months	Cost (€)	Man-months	Cost (€)	Man-months	Cost (€)
Internal	50	600,000	16	120,000	15	180,000	5	60,000
External	12	216,000	2	36,000	6	108,000	0.5	9,000
Software	-	25,000	-	5,000	-	25,000	-	5,000
Total		**841,000**		**161,000**		**313,000**		**74,000**

Benefits and potential cost savings. By implementing the PCS for the scenarios it is expected that more standardised products will be sold and the quality of the specification will improve. That should have a positive impact on the material consumption, production hours, engineering hours, commissioning and carry over work. It should be noted that the commissioning and the carry over work only apply to the complete system projects. The impact on these factors was estimated in terms of conservative, realistic and optimistic for both the scenarios. In Table 6 the potential cost savings on yearly base are indicated for the complete systems project and single equipment project.

Table 6 Potential annual cost savings from implementing a PCS

	Projects			Single equipment sales		
	Conservative	Realistic	Optimistic	Conservative	Realistic	Optimistic
Material consumption	**1%** € 556,550	**3%** € 1,669,651	**5%** € 2,782,752	**1%** € 59,270	**3%** € 177,811	**5%** € 296,352
Production hours	**3%** € 936,633	**5%** € 1,561,056	**8%** € 2,497,690	**3%** € 29,030	**5%** € 48,384	**8%** € 77,414
Engineering hours	**3%** € 882,336	**10%** € 1,764,672	**15%** € 2,647,008	**3%** € 72,578	**10%** € 21,772	**15%** € 36,288
Commissioning	**10%** € 1,764,672	**15%** € 2,647,008	**20%** € 3,529,344		N/A	
Carry over work	**20%** € 814,464	**40%** € 1,628,928	**60%** € 2,443,392		N/A	
Total	**€4,954,655**	**€9,271,315**	**€13,900,186**	**€160,878**	**€247,967**	**€410,054**

Selection of scenarios. Based on these analyses it was decided to select the scenario for the complete system projects as much greater cost savings can be achieved. The conservative case indicates potential savings of € 4,954,656 while the development cost accounts for € 841,000 and the yearly maintenance cost for € 161,000. Therefore the potential benefits are much greater than the anticipated cost.

6 Conclusion and Discussion

The aim of this paper is to offer a more comprehensive framework for ETO companies to identify profitable areas for applying PCS to support the specification processes. The framework consists of three phases where the first phase is where analysis of profitability and accuracy of cost estimation is performed and identification of factors causing deviations in the cost estimations and influencing the profitability. In the second step different scenarios are generated along with the scope of the PCS for the different scenarios. Finally, cost benefit analyses are made to identify the most promising areas for applying a PCS. The framework was applied in an ETO company where it gave a structured approach. The analysis revealed of projects profitability revealed a reduction in the CM of € 101.304 million from what was expected in the budgetary offers for the complete system projects as a result of inaccuracy in the cost estimations. As the analysis in the first phase indicated that the company could benefit from implementing PCS both for complete rig projects as well as single equipment sale, which represent the two scenarios generated. Based on the cost-benefit analysis a significant savings were identified for the complete system projects. Furthermore, the PCS is thought to also influence positively on other factors that could not be quantified such as potential extra sales as the company is able to respond quicker to customer's enquiry, more professional dialog with the customers and to enable market driven standardization of the product range. However there are some limitations to this study as the framework has only been applied in one case company and therefore further testing to improve the framework and achieve generalizability is required.

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