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# Product cost analysis in early stages of a product development process

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# Abstract

On a global market with tighter gross margins the focus on product cost have increased. A demand for improved methods within product cost calculations in the product development process is important to sustain competitive.

Product cost is a vital part of a company's cost base. During a product development process early stage there is often a lack of established methods and processes for calculation of the product cost. Especially difficult is it to estimate product cost in early stages of the product development process when the uncertainty around the construction of the product is big. That might lead to lack of knowledge around material cost and need of investments occur. The goal with this thesis is to help, evaluate and support around improvements within the product development projects when it comes to product cost calculation.

The purpose of this thesis is to create a suitable financial model that is applicable when choosing concept in early stages of the product development process to sustain highest possible profitability for Volvo Construction Equipment. To solve this problem a collection of theory in form of books, articles and reports has been made with focus on product development and product cost. The theory part showed a lot of material around the product development process but less data around detailed product cost calculation. The empirical part has been created in cooperation with Volvo Construction Equipment with purpose to increase knowledge for problems in its natural environment. From interviews, documentations and other collection has shown that improvement potential was found for product cost calculations in early stages of product development project.

For further increased understanding a structured comparison and a discussion around each area of theory and empirical data was created. The result of the comparison shows that Volvo Construction Equipment's handling of problems correlates with the theory that exists in the thesis.

To improve the process with product development and product cost calculation at Volvo Construction Equipment a calculation model was created. The model was applied in a real product development project in the company and gave opportunity for estimations of the development of the product cost during the different stages of the project.

# Sammanfattning

På en global marknad med allt tightare vinstmarginaler har fokus på produktkostnad ökat. I produktutvecklingsprocessen har ett allt större behov av förbättrade arbetssätt kring produktkostnadskalkylering uppstått för att företag skall vara konkurrenskraftiga.

Produktkostnad är en väsentlig del av ett företags kostnads massa. Under en produktutvecklingsprocess tidiga skeden saknas ofta etablerade metoder och processer för beräkning av produktens kostnad. Speciellt svårt är det att uppskatta produktkostnad i tidiga faser av produktutvecklingsprocessen då osäkerheten kring konstruktionen är stor. Detta kan få till följd att till exempel avsaknad av vetskap kring materialkostnad eller investeringsbehov uppstår. Målet med denna uppsats är att hjälpa, utvärdera och supportera kring förbättringar av arbetssätt inom produktutvecklingsprojekten när det kommer till produktkostnadskalkylering.

Syftet med detta examensarbete är att skapa en passande finansiell modell som kan användas vid val av koncept i tidiga stadier av produktutvecklingsprocessen för att säkerställa högsta möjliga lönsamhet för Volvo Construction Equipment. För att lösa detta problem så har insamling av teori i form av böcker, artiklar samt rapporter genomförts med fokus på produktutveckling och produktkostnad. Teoristudien påvisade mycket material kring produktutvecklingsprocessen men mindre kring detaljerad produktkostnadskalkylering. Den empiriska delen har genomförts i samarbete med Volvo Construction Equipment med syfte att få ökad förståelse för problemställningar i dess verkliga miljö. Från intervjuer, dokumentation samt övrig insamling så påvisades att förbättringspotential fanns kring produktkostnadskalkylering i tidiga faser av produktutvecklingsprojekt.

För ytterligare ökad förståelse genomfördes en strukturerad jämförelse samt en diskussion kring respektive område av teori och empiri. Resultatet av jämförelsen visar att Volvo Construction Equipments hantering av problem korrelerar med den teori som existerar i uppsatsen. I de situationer där Volvo avviker från teorin så finns orsaker till att företaget inte väljer att följa denna.

För att förbättra processen kring produktutveckling och produktkostnadskalkylering på Volvo Construction Equipment skapades en kalkylmodell. Modellen applicerades konkret i ett pågående produktutvecklingsprojekt i företaget och gav möjlighet till uppföljning av utvecklingen av produktkostnaden under de olika faserna av projektet.

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A special thanks also to Associate professor Magnus Wiktorsson and to Volvo Construction Equipment Operations Eskilstuna and Arvika.

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Arvika, mars 2013

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# 1. Introduction

## 1.1 Background

This thesis will be written together with the Industrialization and Production development department at Volvo Construction Equipment (Volvo CE) in Eskilstuna. Volvo CE is a part of the Volvo Group which is a major actor within transport solutions with products as trucks, busses, construction equipment drive lines for marine and industry applications and components for airplane engines. The Volvo Group consists of 19 different companies where Volvo CE is the second biggest part. Volvo CE produces Wheel Loaders, Articulated Haulers, Excavators and other machines for the construction equipment industry, see Figure 1 below.

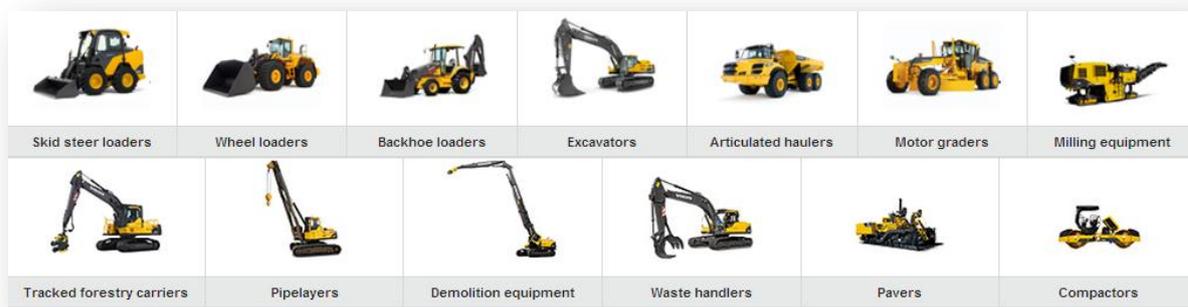


Figure 1, Construction Equipment reference: Volvo (2011)

The division called Operations, which is the biggest part of Volvo CE, is assigned to produce the different machines in the product portfolio. The Eskilstuna plant produces transmissions and axles. The plant consists of advanced manufacturing, paint shop, hardening, testing and an assembly line.

The department Industrialization and Product development, where the thesis will be written, is organized under the department production engineering which is a part of Operations.

The Industrialization and Production development department's tasks are:

- Manage and develop the process for production development within Operations Eskilstuna.
- Manage projects within Industrialization when launching new product projects.

Operations Eskilstuna produces transmissions and axles to Wheel Loaders, Articulated Haulers and Motor Graders. In purpose to create a plant with focus on Lean Production the management decided to invest and rebuild the plant during 2007-2009. CS-09 (Components Steps 2009) which was the name of the project was focusing on optimizing the production approach for the plant.

In 2010 a new product development project called NTP (New Transmission Platform) started. The purpose is to develop a new transmission platform for the majority of the company's products. Today the plant produces several transmission types which result in different assembly and fabrication procedures. The consequences of this could be increased manufacturing cost in form of machine cost, personnel cost, consumables and maintenance comparing to what a common transmission platform. The NTP project gives the company an opportunity to create this platform. A lot of suggestions on concept solutions have been created which can be used for different sorts of machines.

### **1.1.1 Problem description**

The competition in the automotive and heavy duty machine industry is increasing with companies fighting for the same customers on a global market. The need to introduce new vehicles more often, in combination with higher customer expectations and increased pricing pressure makes the situation really challenging. Morgan and Liker, 2006 also point out the situation as because auto companies are introducing more vehicles more often, and are simultaneously facing higher quality expectations and increasing pricing pressure; they have less time to improve quality and manufacturing productivity. There is a smaller margin for error: New vehicle introductions cannot result in a drop in vehicle quality. With shortened model life spans, companies can no longer afford a spike in defects and or a leisurely hours per vehicle pace. An effective product development process and capability that produces world class products and production systems has become a strategic differentiator. Whereas the performance gap in manufacturing is closing, the gap between best-in-class and the rest of the automotive industry in product development is increasing (Morgan and Liker 2006). To do the right things from the beginning of a product development process is becoming more and more important to remain competitive. This includes selecting the most promising solutions of products and production system concepts. To support this work in early phases there has been an identified need at Volvo construction equipment to create a description of a model for estimation of the product cost in very early stages of the product development process. The model is needed in general for all projects that are being industrialized in the Eskilstuna and Arvika plants and especially also for the NTP project.

The NTP-project can be classified as a big project for Volvo CE with a lot of functions involved. Meetings and groups are created in different parts of the company. The functions Industrialization and production development, after market, purchasing and technology are all involved in the project of develop a new transmission platform. Project leaders from different parts of the organization are gathered in meetings where assignments and follow up are on the agenda. These assignments are then the fundamentals for the meetings that the project leaders for the different parts of the organization are organizing. One example is the project leader for the industrialization department who arranging meetings with material controllers, production engineers, quality leaders and methodology engineers.

In relation to the phases of the product development process, at Volvo called GDP (Global Development Process), the NTP project lies in the pre study phase and on the way into the concept development phase (see chapter 4). Today the project has 30 Transmission concepts divided in nine families. Family in this case means same technical solution. One goal in the project is to decrease the number of concepts to ease up the work in the project. The elimination of concepts is achieved by cooperation between all involved functions. The different concepts are today on very different maturity levels. Some have CAD models while others just have power point drawings. There is a need of early analyses from the production engineering and different departments to create sustainable information for the elimination process. The Industrialization and product development departments' role in the project is to validate the different concepts effect on the production set up.

To cut down the number of concepts is important to manage the projects time schedule. The different phases of the GDP are not only the fundamentals for the development progress, but also for the entire projects time table. Earlier experiences have shown that if one phase tends to take more time than expected the industrialization phase will suffer. To decrease the number of concepts to an achievable level will lead to a lot of time savings and also make the

industrialization phase to be achieved in a proper way. However it is important to clearly describe why a concept is being eliminated so that there will be no misunderstanding's later in the project. The documentation is vital as precaution so that a potential successful concept will not be eliminated by mistake during the project.

Thou the project is huge and involves several functions a well-organized cooperation between the functions is vital for success. The cooperation between the different functions is something that is on the agenda for the meetings mentioned earlier. Cooperation is necessary and something that the GDP structures are focusing on for the finished product to satisfy all functions, customers and other interest. One of the expected results from this cooperation is an agreement about consequences from different perspectives and an estimation of the product cost. Product cost is one of the most important evaluation and concept selecting criteria's in the product development projects at Volvo for assuring sustainable profitability and therefore there the author and the company supervisor have agreed about the following objective for this thesis.

## ***1.2 Objective***

Create a suitable financial model that can be used when choosing a concept in early stages in the product development process to secure highest possible profit for Volvo Construction Equipment.

## ***1.3 Researched questions***

To highlight the consequences on the production system when implementing different variants of a common product platform there has been three Research Questions (RQ) created to summary the objective of the work:

- RQ1: What are suitable business models today?
- RQ2: How should allocation of overhead and fixed costs in a product cost calculation scenario work today?
- RQ3: How can a financial model support early decisions in a product development project?

## ***1.4 Delimitations***

To delimitate the workload and set the system boundaries for this thesis the following early delimitations were created:

- The limitation to answer and analyze my questions will only include the Volvo CE plants within Sweden.
- The analyze of current state will only include the New Transmission Project as a case.
- The thesis will only reflect the cost included in the product cost. The product cost belongs to the organization Operations. Operations from this project perspective include production and purchasing.
- Follow the Volvo Group regulations for profitability calculations in projects.

## 2. Methodology

This chapter describes the applied research methodology in this thesis project.

### 2.1 Research approach

The objective and three research questions created in chapter 1 summarize the task and are the fundamentals of the thesis. Based on the questions and the thesis purpose the learning process started. The background of the author as a business controller at the company together with a clearly identified industrial need made the empirical context the starting point of the research/learning process. During the work with the thesis the data collection switched between empirical and theoretical knowledge. In that way a comparison between what the theories are saying and practical experience was created. A schematic schedule of the research approach and process is shown in figure 2 below from (Eriksson, 2009).

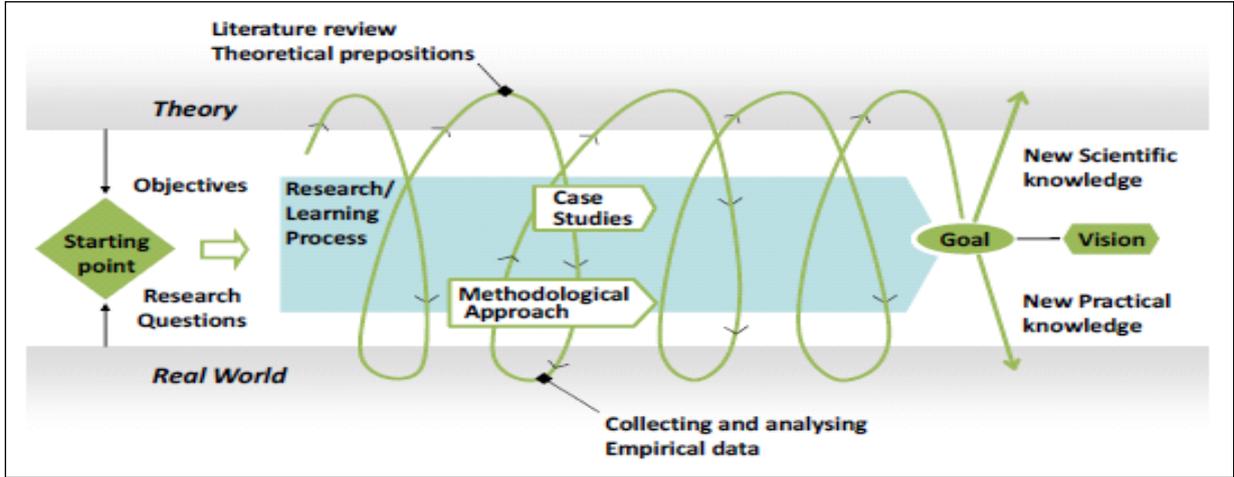


Figure 2 – Schematic schedule of the process, Eriksson (2009)

### 2.2 Research method

Based upon the type of research question, the extent of control the author had over actual behavioral events and the degree of focus on contemporary as opposed to historical events, a case study approach was chosen for the work in this thesis (Yin, 2009). There were two case projects from the company included in the work with this thesis. One project NTP is studied in the beginning for better understanding of the current state situation and the other case project CAST were used later for test of a suggested improved way of working.

| METHOD            | (1)<br>Form of Research Question      | (2)<br>Requires Control of Behavioral Events? | (3)<br>Focuses on Contemporary Events? |
|-------------------|---------------------------------------|---|--|
| Experiment        | how, why?                             | yes   | yes                                    |
| Survey            | who, what, where, how many, how much? | no  | yes                                    |
| Archival Analysis | who, what, where, how many, how much? | no  | yes/no                                 |
| History           | how, why?                             | no  | no                                     |
| Case Study        | how, why?                             | no  | yes                                    |

Figure 3 – Relevant situations for different research methods (Yin, 2009)

## 2.3 Design Research Methodology

### 2.3.1 DRM classification of the research

The work in this thesis could be classified with help from DRM, a Design Research Methodology (Blessing, 2009) as a type 2 design research project. A Research clarification stage was followed by a Descriptive study phase together with an Initial Prescriptive study suggesting how the findings could be used to improve design. This classification was help for setting a realistic target for the thesis work in relation to time and resources available.

| Research Clarification | Descriptive Study I | Prescriptive Study                          | Descriptive Study II |
|------------------------|---------------------|---|----------------------|
| 1. Review-based        | → Comprehensive     |   |                      |
| 2. Review-based        | → Comprehensive     | → Initial                                   |                      |
| 3. Review-based        | → Review-based      | → Comprehensive                             | → Initial            |
| 4. Review-based        | → Review-based      | → Review-based<br>Initial/<br>Comprehensive | → Comprehensive      |
| 5. Review-based        | → Comprehensive     | → Comprehensive                             | → Initial            |
| 6. Review-based        | → Review-based      | → Comprehensive                             | → Comprehensive      |
| 7. Review-based        | → Comprehensive     | → Comprehensive                             | → Comprehensive      |

Figure 4 - Types of design research projects and their main focus. (Iterations omitted) (Blessing 2009)

In figure 5 below there is an overview of how the different chapters in the thesis are connected to the different phases in the Design Research Methodology and the activities in each phase are further described below in chapter 2.3.2.

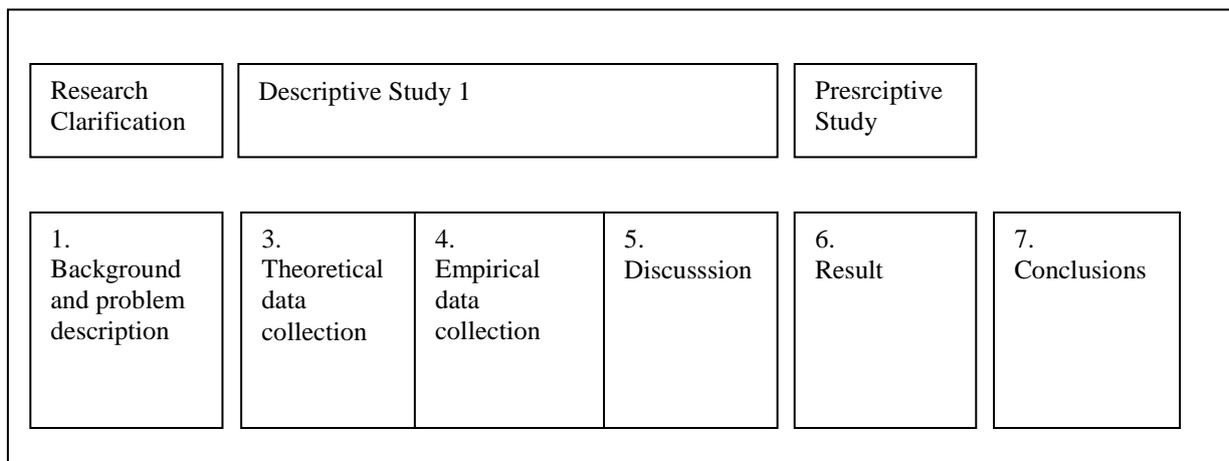


Figure 5 - overview of the chapters in the thesis in relation to the phases in DRM

### **2.3.2 Description of activities**

The activities performed in each phase are further described below:

#### **Research Clarification phase**

The thesis work started from an industrial identified need for improvement and based on that, the objective, research questions, and delimitations were formulated. This work (chapter1) was done by the author together with the supervisor of the thesis.

#### **Descriptive Study 1**

In the descriptive study1 the author collected empirical data (chapter4) from the case project NTP together with standard information used at the company for all projects. Several sources of evidence were used when collecting the data (Yin, 2009). The author used documents, interviews and direct observations. The empirical literature part consists of earlier investigations made by the company and internal education material. A complementing interview was also performed with an experienced person outside the company for increased understanding of the studied topic in general. For increased understanding the author also carried out a theoretical study about important aspects of the research questions (chapter3). To create a theoretical framework for the thesis, literature in relevant areas in form of scientific reports, books and other thesis's were studied. A significant part of the theoretical part of the data collection was about validating what data that is relevant for the thesis. With support from the company and own experiences a first selection of data was be made. Thou the learning process worked parallel with the thesis work, it was of importance to shift focus between theory and empirical to avoid missing important parts. The goal of continuously shifting between theory and empirical parts was to create a good framework for the rest of the thesis work. Finally in the descriptive study phase the empirical and theoretical findings were compared and discussed (chapter5).

#### **Prescriptive Study**

In an Initial Prescriptive study the author suggest how the findings from descriptive study1 could be used to improve the way of working with a financial model support early decisions in a product development project. A model was created, validated before test with two experienced financial managers, and finally tested in case 2, the CAST project. To sum up a discussion about the model ends up this phase.

#### **Conclusions**

In the last part of this thesis (chapter 7) the author summarizes and discusses how well the different research questions and the objective are fulfilled. Thoughts about industrial and academically relevance together with suggestions for further research are also highlighted.

## ***2.4 Validity and reliability***

Validity and reliability are two parameters used for judging the quality of the research work.

Validity describes with what precision the research work measures what it is supposed to measure, (Wallén, 1996, p.65). The reliability describes the precision the studied parameters are measured in, according to (Wallén, 1996, p.66). Good validity and reliability are necessary tools for generalizing the research results. The reliability is about how well a measurement or study can be repeated it is very important to know how the measurements have been performed. Transparency is one way to enhance the reliability. It allows and enables other researchers to do the research; this transparency can be achieved by describing the methodology used in this research. The author has tried to describe the different steps and approaches used in this thesis work in this chapter 2 for increased transparency.

### 3. Theoretical Framework

#### 3.1 Stage-Gate Product development process

In many companies today product development follows a stage-gate product development process with several phases and gates like the one (Cooper, 2008) describes in Figure 6 below.

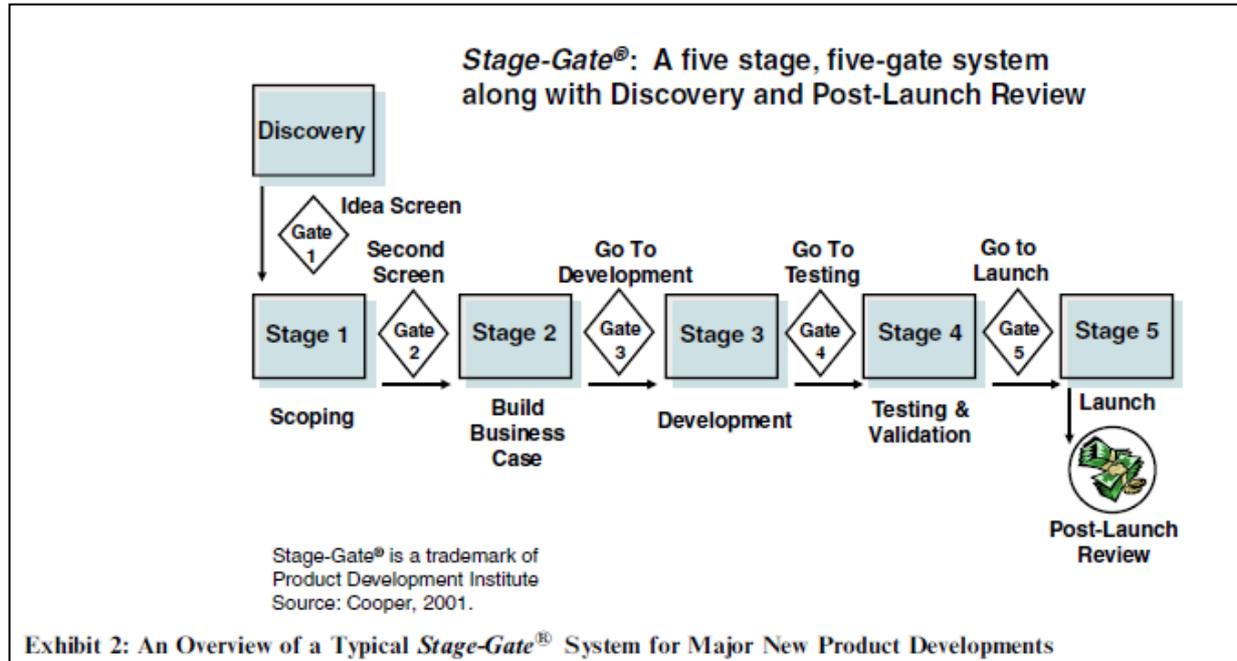


Figure 6 - Stage-Gate process

#### 3.2 Lean product development

Normally companies are trying to work cross functionally in the different phases to create as effective and profitable products and production system as possible from the beginning and in early phases in the product development process. The approach of achieving the goal may vary and one way of changing the process in early stages of the development process is to try to implement Lean product development and the principles with Set-Based Concurrent Engineering. This is something that Toyota and its suppliers implemented with great success. Figure 7 describes in an easy way the five steps of the Lean product development process. (Holmdahl, 2010).

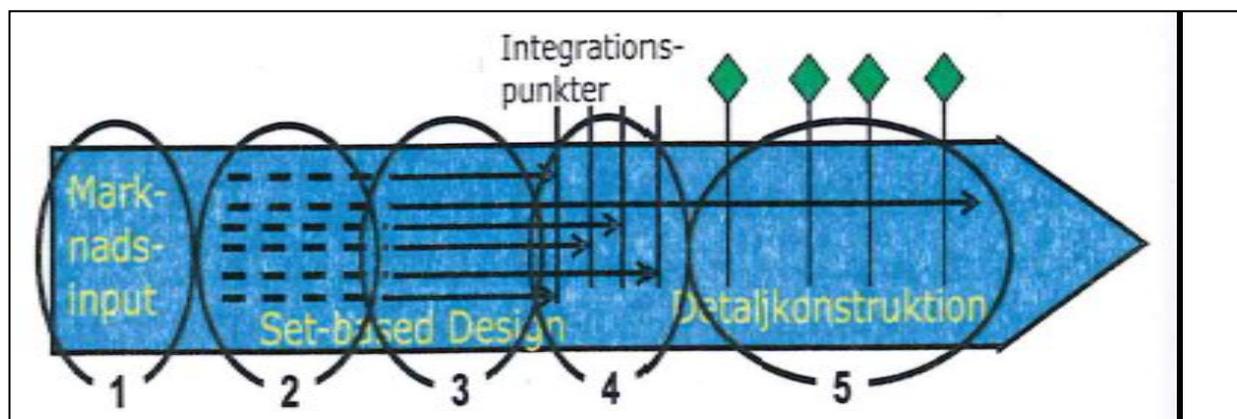


Figure 7. Lean product development process

The five main phases of Lean product development process described in Figure 7 is:

- Phase 1 Project starts
- Phase 2 Concept development
- Phase 3 Set-Based design
- Phase 4 Integrations points
- Phase 5 Detail construction.

Phase 3 Set-Based design means according to Holmdahl that you "work with a large number of parallel tracks which eliminates additions and guaranties almost optimal system success".

### 3.3 Product platforms

Another common method within product development is to divide the product families in different product platforms and try to re-use different modules and article numbers in the design to in that way achieve higher volumes in the plants flows and to reach new market segments, see example 3 figure 8 below from (Simpson, 2001). Advantages with this approach can be seen thru the entire life cycle of the product, from product development, purchasing thru production and aftermarket.

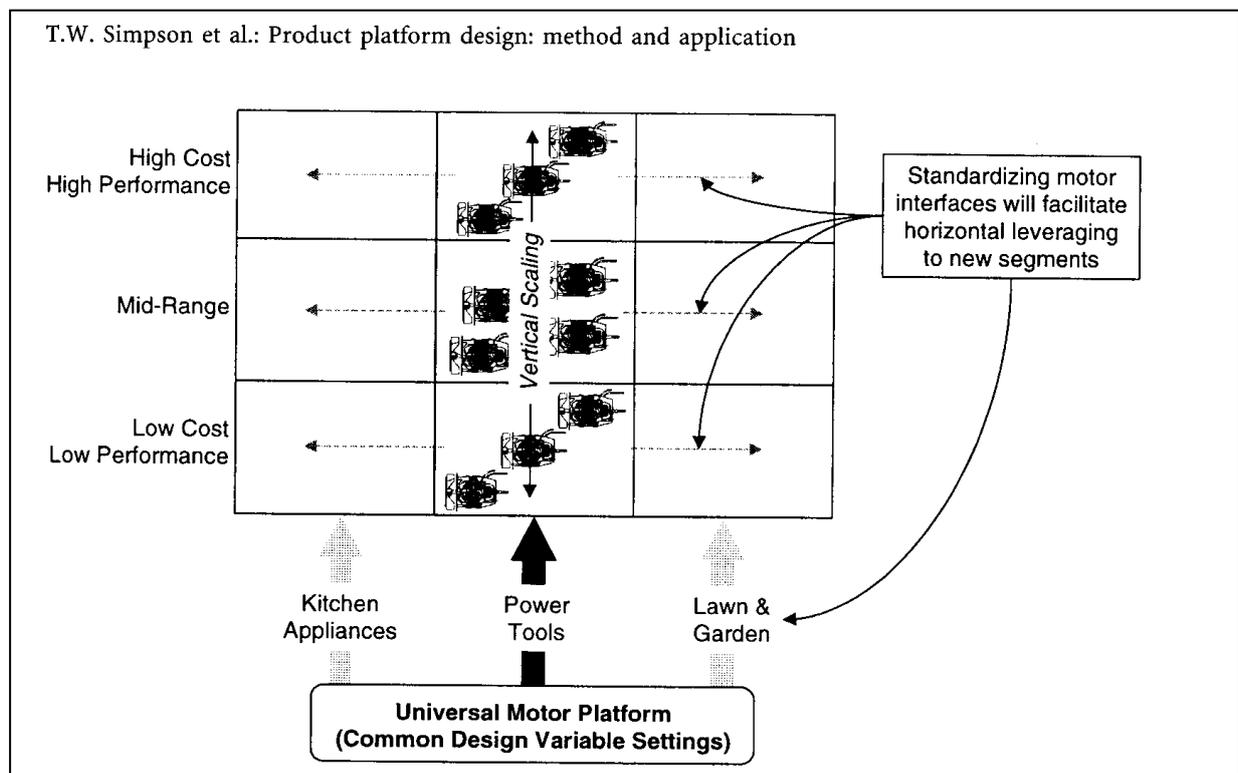


Figure 8. Product platform design

### 3.4 Business case calculations

There can be different reasons for concept evaluation. For example technical solutions, news bulletins or flow changes. Inevitably the costs are compared for different alternative during the evaluation. In normal cases cost per unit is used to compare cost for products, but also to compare cost per product family, product program, department, plants or entire economies of a company can be used (Fixson, 2002).

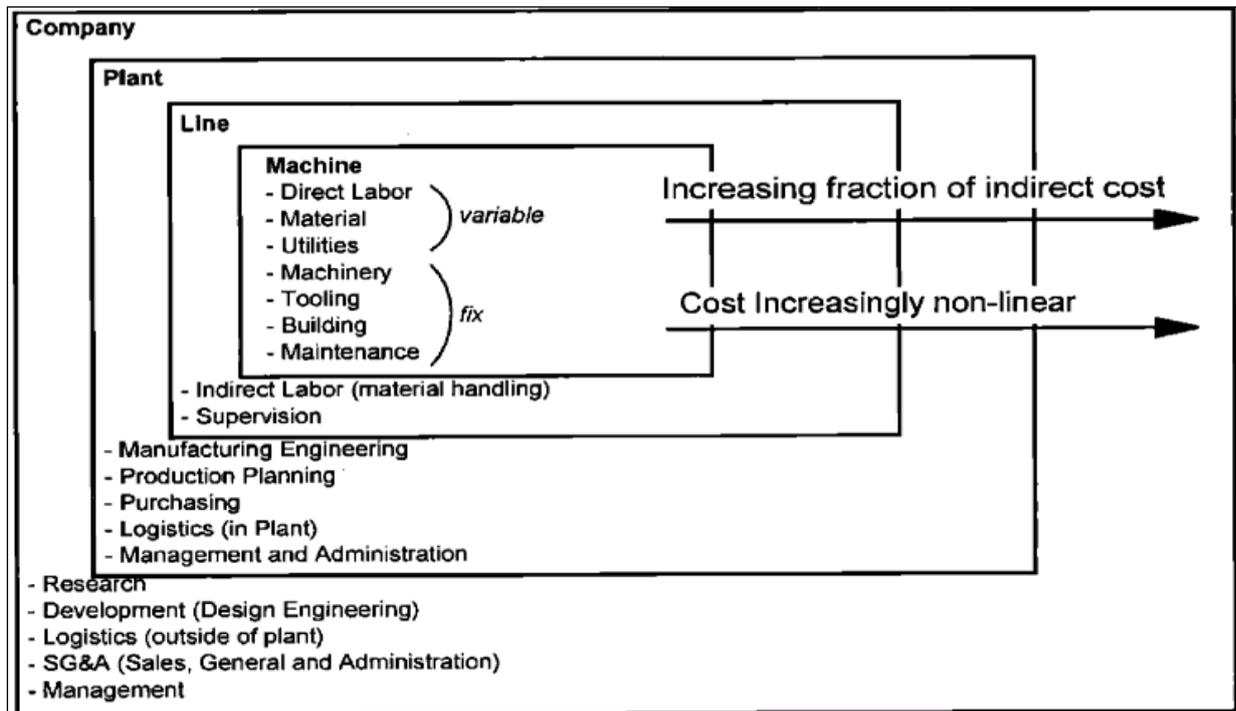


Figure 9 – Different levels of cost analyses Fixson (2002)

Figure 9 shows how costs are allocated to different levels. Analysis may occur on corporate, plant, working cell/line or machine level depending on if the analysis shall focus on direct cost (e.g. material demand or direct labor) or remove cost (e.g. plant safety salary) for a product (Fixson, 2002).

### 3.5 Cash Flow

Cash flow gives a direct connection to the organizations liquidity. A financial analysis who describes the change in liquidity shows the organizations short time solvency. The term liquid assets vary depending on the underlying time that will be accepted by the derivate included (Falkman, 2000).

Example of cash management actions done by companies working in projects to reduce capital tied up and improve the cash flow is:

- Quotation and order handling that affect the receivables in the balance sheet.
- Credit and payment terms that effect receivables in balance sheet.
- Receivables that affects receivables in the balance sheet.
- Payment routines that affects the receivables and cash in the balance sheet.
- Payments that affects payables and cash in the balance sheet.

Besides the actions above, earlier research about purchasing that affects inventory and payables in the balance sheet and effective production that will affect inventory in the balance sheet should be affective for the purpose of the study (Bennet, 2003). With the direct connection to the organizations liquidity and solvency, the influence on cash flow could be an important factor to consider in product development project evaluations too, when choosing between product and production system concept solutions.

### **3.6 Business case model**

A sustainable business case compared with an ordinary conventional show and realizing profitability through an intelligent design. The intelligent design also involves creation of sustainable product and production system design solutions. Sustainable business cases are characterized by three parts that needs to be fulfilled (Schaltegger and Wagner, 2006).

- The company needs to create, voluntarily and partly voluntarily, activity with the intention to contribute with solutions. The activities is planned for the environment and not adapted after legal or financial demands as a part of an ordinary business behavior.
- The number two activity must create a positive effect on the company's business that can be measured and motivated in a suitable way. Examples on effects could be cost savings, sales increases and increased competitiveness. Other effects are increased profitability and improved goodwill.
- The third part, a clear and convincing argumentation must occur. Also a particular management activity leads to or will lead to a financial or an effect on the company business. It takes good business understanding and knowledge about profitability to create a sustainable business case. Also management needs a good information platform that supports the creation of a business case.

### **3.7 Product cost**

Product Costs are almost all variable costs. Some of the sources of variability relate to physical volume of items produced. These costs will vary with units produced, or in a varied, multiproduct environment, with surrogate measures such as labor hours, machine hours, material dollars and quantities, or elapsed time of production. Other cost, however, particularly those arising from overhead support and marketing departments, vary with the diversity and complexity in the product line. The variability of these costs is best explained by the incidence of transactions to initiate the next stage in the production, logistics, or distribution process (Bruns and Kaplan, 2007).

A comprehensive product-cost system, incorporating the long term variable costs of manufacturing and marketing each product or product line, should provide a much better basis for managerial decisions on pricing, introducing, discontinuing and reengineering product lines. The cost system may even become strategically important for running the business and creating sustainable competitive advantages for the firm (Bruns, et. al. 2007)

In a full-cost system, fixed production costs are allocated to products. Reported product costs are meant to reflect the total cost of manufacture. In a variable-cost system, the fixed costs are not allocated; reported product costs are meant to reflect the marginal cost of manufacturing firm (Bruns, et. al. 2007).

Academic accountants, supported by economists, have argued strongly those variable costs are the relevant one for product decisions. They have demonstrated, using increasingly complex models, that setting marginal revenues equal to marginal cost will produce the highest profit. In contrast, accountants in practice continue to report full costs in their cost accounting systems firm (Bruns, et. al. 2007).

Another major difference between the two approaches is the time frame over which the product decisions are made. The definition of variable cost that academic accountants use assumes that

product decisions have a short time horizon, typically a month or a quarter. Cost are variable if, and only if, they vary directly with monthly or quarterly changes in production volumes. Such a definition is appropriate if the volume of production of all products can be changed at will and there is no way to change simultaneously the level of fixed costs (Bruns, et. al. 2007).

In practice, managers reject this short-term perspective. In their eyes, the decision to manufacture a product creates a long-term commitment to manufacture market and support that product. Given this perspective, short-term variable cost is an insufficient measure of product cost. Indeed, a long-term measure is required.

While full cost is meant to be a surrogate for long-run manufacturing cost, in nearly all of the companies visited, management was not convinced that their full-cost systems were adequate for product-related decisions. In particular, management did not believe that their systems accurately reflected the costs of resources consumed to manufacture products. But they were also unwilling to adopt a variable-cost approach. The goal of a study, therefore, was to determine a relevant measure of product costs that would facilitate product decisions. Conclusion is that almost all products related decisions introduction, pricing and discontinuance are long term decisions. The short-term focus for product costing has led to the situation of a large and growing proportion of total manufacturing cost is considered “fixed”. This paradox that was called “fixed” costs is in fact the most variable and rapidly increasing cost. The key for unlocking the paradox arises from introducing two fundamental changes in our thinking about cost behavior.

First, the allocation of costs from the cost pools to the products should be achieved using bases that reflect cost drivers. Since many overhead costs are driven by the complexity of production, not the volume of production, non-volume related bases are required.

Second, many of those costs are somewhat discretionary, and while they vary with changes in the complexity of the production process, these changes are intermittent.

A traditional cost system that defines variable costs as varying in the short term with production volume will misclassify them as fixed costs. The misclassification arises from an inadequate understanding of the actual cost drivers for most overhead cost (Bruns, et. al. 2007).

### 3.8 Product Cost Estimation Techniques

Good cost estimation has a direct bearing on the performance and effectiveness of a business enterprise because overestimation of result in loss of business and goodwill in the market, whereas underestimation may lead toward financial losses to the enterprise. Because of this sensitive and crucial role in an organization, cost estimation has been a local point for design and operational strategies and a key agenda for managerial policies and business decisions (Niazi, et. al. 2006).

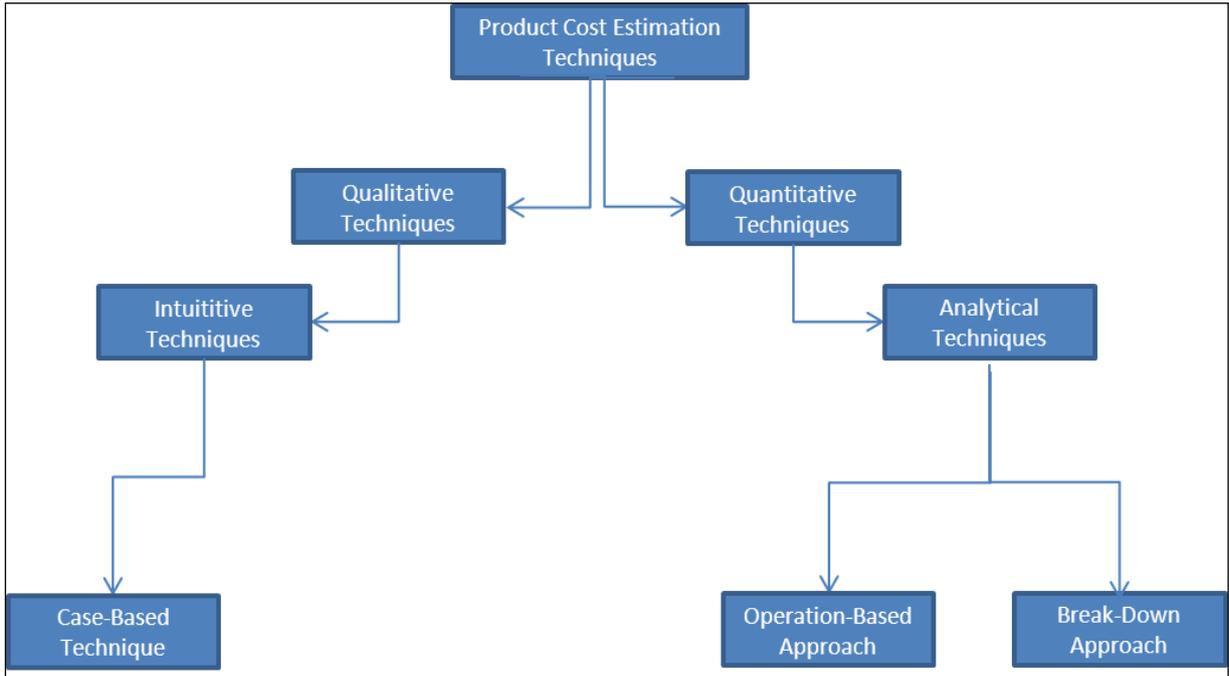


Figure 10. Product cost estimation Techniques Niazi et.al

The paper by (Niazi, et.al, 2006) provides a detailed review of the state of the art in product cost estimation covering various techniques and methodologies developed over the years. The overall work is categorized into qualitative and quantitative techniques. The qualitative techniques are further subdivided into intuitive and analogical techniques, and the quantitative ones into parametric and analytical techniques.

Qualitative cost estimation techniques are primarily based on a comparison analysis of a new product with the products that have been manufactured previously in order to identify the similarities in the new one. In general qualitative techniques help to obtain rough estimates during the design conceptualization(Niazi et.al, 2006).

Quantitative techniques, on the other hand, are based on a detailed analysis of a product design, its features, and corresponding manufactured processes instead of simply relying on the past data or knowledge of an estimator. Cost are, therefore, either calculated using an analytical function of certain variables representing different product parameters or as the sum of elementary units representing different resources consumed during a whole production cycle of a given product. Although these techniques are restricted to the final phases in the design cycle, due to the requirement of a detailed product design. Quantitative techniques can be further categorized into parametric and analytical techniques (Niazi et.al, 2006)

### 3.9 Lean Accounting

Within Lean accounting e.g. in the book Practical Lean Accounting (2011) written by Brian Maskell among others pin points the importance of consider the entire cost of the value stream. Picture 6 below is an example of that point of view where all costs for personnel, material, machines, support functions and real estates that are allocated direct in the value stream. Worth to note is that all personnel that supports the value stream shall be added in the calculation and that it shall not be any difference between production personnel cost and other support costs. In this case there little or no allocation of cost. The average cost per unit is calculated by the entire cost of the value stream on production week divided by sent units to customers the same week. Another way to calculate the average value added cost per unit (Value added cost is the total cost in the value stream except the material cost). If the products are similar with similar material cost than the average of the total cost approach suitable. If the products have different material cost but similar production process so is the average value added cost in the value stream more useful. In the same time the authors focus on “the best way of reducing cost is to increase the sales without adding more resources; that is a lean way to go”.

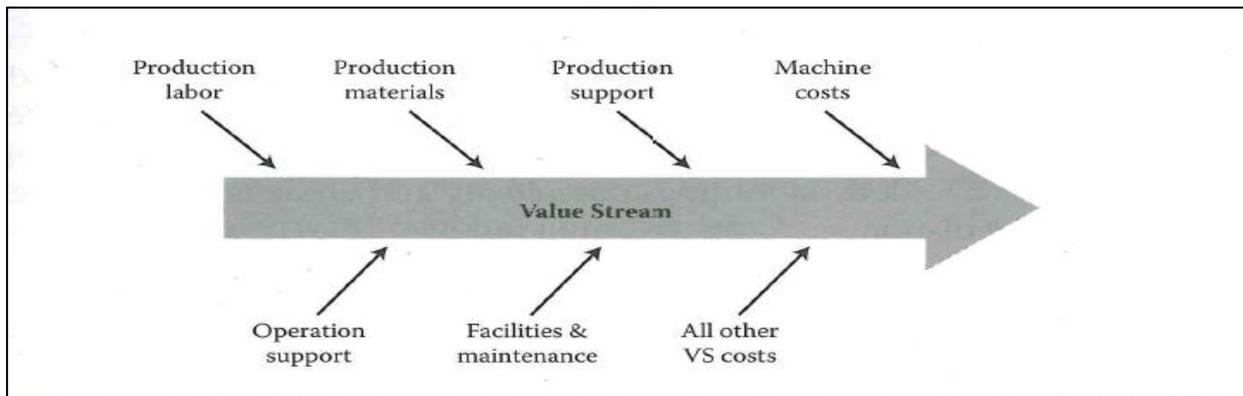


Figure 11. Value stream cost

### 3.10 Product cost calculation consequences

In the article Product life cycle cost analysis: State of the art review written by (Asiedu and Gu, 1998) describes the “The Freiman curve” from (Daschbach and Apgar, 1988) showed in picture 7 below. The point with this curve is to describe the consequences of mistakes in calculations of costs. In a competitive situation if the company estimates its costs unrealistically low to win an order, but risk to do a financial loss. On the other way an over estimation of cost may result in loss of orders. The precision on the cost estimates is therefore vital for an organizations survival.

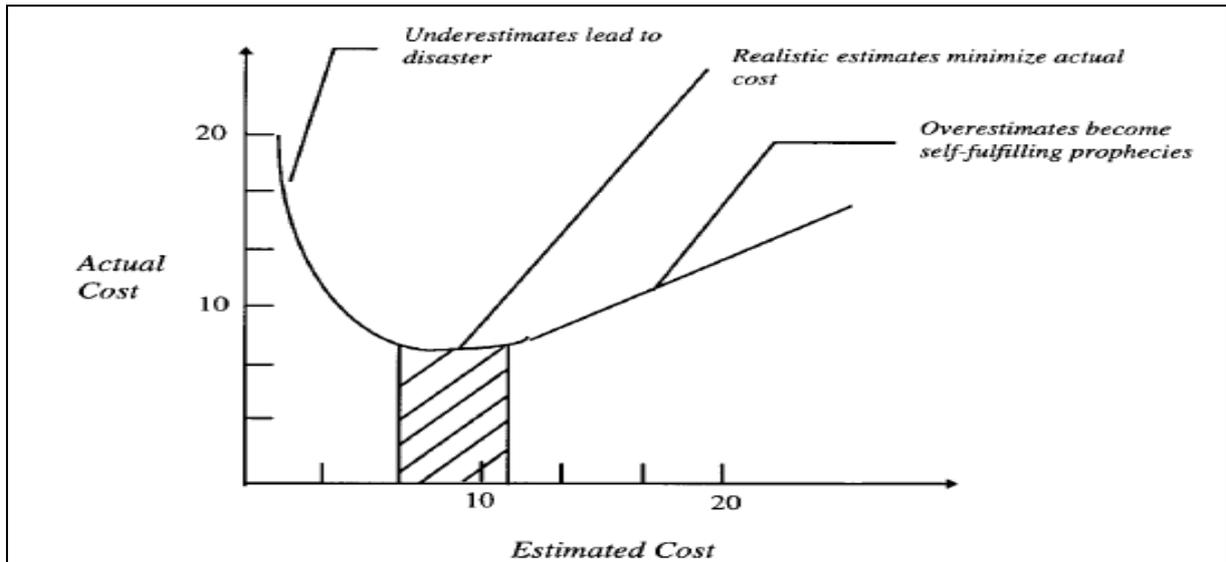


Figure 12. The Freiman curve

The graph shows that:

1. The bigger under estimation, the higher actual cost.
2. The bigger over estimation, the higher actual cost
3. The most realistic estimation results in the most economic project cost.

### **3.11 Activity Based Costing**

The core principle of this model is a joint definition of activities and cost drivers in order to determine the cost-effective consequences of any process reconfiguration. (Dekker and van Goor, 2000)

The developed process scheme and underlying cost allocation is too complex to optimize all factors at once, the defined processes and cost drivers can be used to evaluate trade-offs. In doing so, it is possible to assess different supply chain design decisions regarding their cost effectiveness. Consequently, managers can assess the total costs of any supply chain modification (Seuring, 2002)

Activity-based costing information is used for pre-development budgeting purposes. This allows a determination of costs during product development and, finally, an evaluation of the performance of the suppliers (Möller and Möller, 2002).

Only a detailed assessment at every level of the supply chain allows distributing costs and benefits equally along the supply chain and leads, finally, to the “optimal” configuration of the supply chain network. Due to the practical relevance of inter-firm cost accounting standards, some researchers have taken up these preconditions and have developed conceptual models for cost accounting in supply chains. Many of these considerations are based on activity-based costing as a related cost management technique (for a critical look at its status of implementation see (Askarany and Yazdifar, 2011).

## 4. Empirical studies

### 4.1 Stage-Gate Product development process

A practical example from Volvo has been studied to compare theory with examples from real life. In this particular example has the case study project “NTP” been chosen were the work is in the concept study phase before Concept Gate (CG) in the company Stage-gate product development process see picture 7 below.

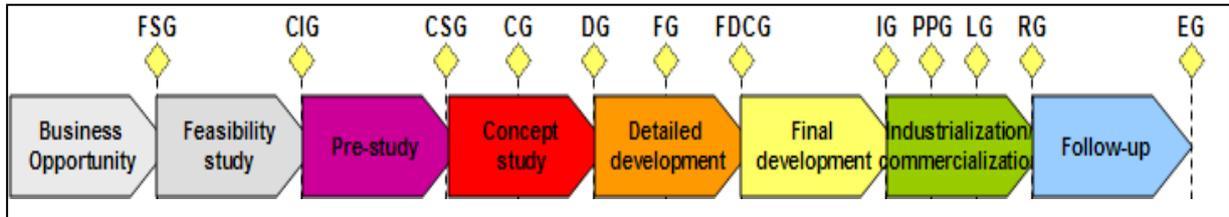


Figure 13. Case study companies Stage gate process

### 4.2 Lean Product development

Volvo are trying to apply a lot of cross functional resources early in the product development process, so called Front-loaded process, and in several projects apply Set-Based Concurrent Engineering principles. In the process of choosing concept there is a focus of continuously eliminating concept solutions instead of chose one final solution and risk expensive loopbacks in the product development process if a solution does not work. Picture 8 below is from the case study company and describes some of the principles considered.

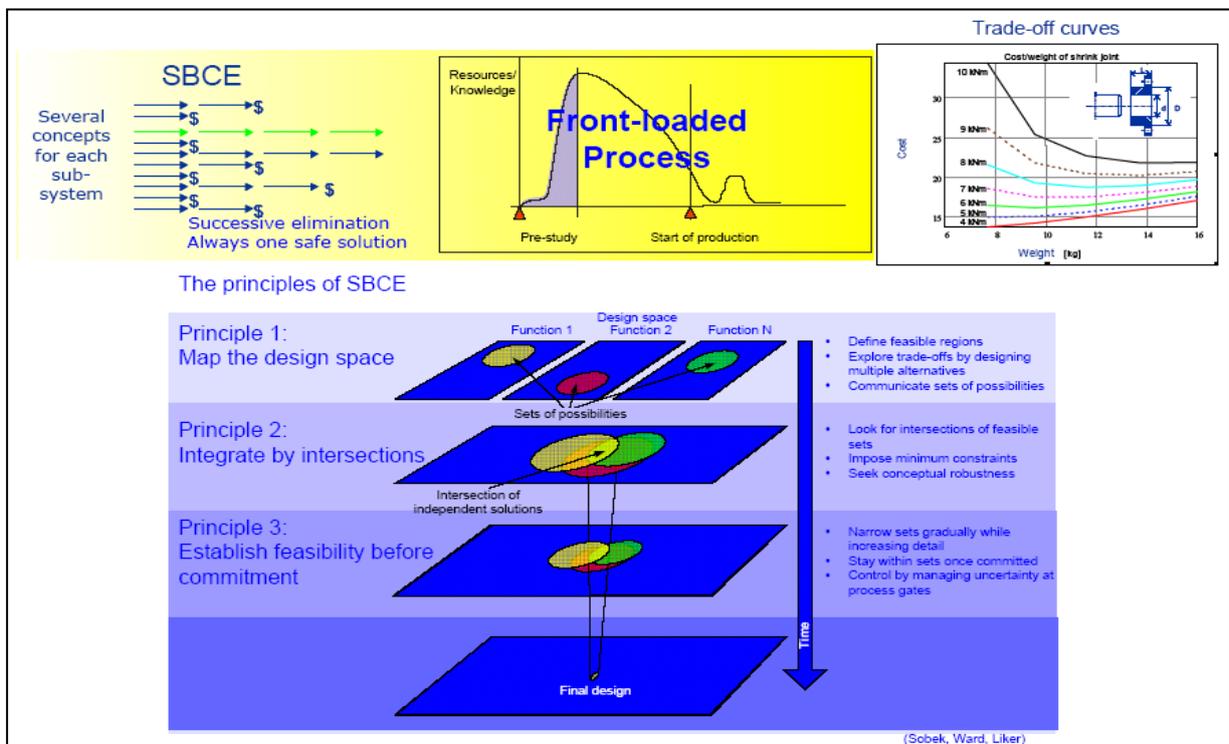


Figure 14. Set-Based Concurrent Engineering from the Volvo.

### 4.3 Product Platforms

Volvo works with platform development and the complexity is high with multiple part system to different products. Examples below in figure 15 show a matrix who describes current situation in the case study project with several scenarios of platform solutions for several products:

| Product   | Scenario1 | Scenario2 | Scenario3 | Scenario4 | Scenario5 | Scenario6 |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Product 1 | Concept A | Concept A | Concept E | Concept E | Concept G | Concept G |
| Product 2 | Concept B | Concept B | Concept F | Concept F | Concept H | Concept H |
| Product 3 | Concept B | Concept B | Concept F | Concept F | Concept H | Concept H |
| Product 4 | Concept C | Concept D | Concept C | Concept D | Concept C | Concept D |

Figure15. Product platform matrix

The challenge for Volvo lies in calculating a correct product cost on scenario level for products above. All of the products above is planned to be produced in a common value stream and the components shall be modularized within the product platform and within each scenario. The material part of the product cost may vary between the concepts.

### 4.4 AB Volvo business case model

The Volvo group official business case model is described below. The model consists of a couple of excel slides:

- In the first slide you shall consider business area, country, discount rate, currencies and calculation period. There are also possibilities to name the different alternatives.
- Each alternative considers four key performance indicators. Net present value, modified internal rate of return, internal rate of return and payback.
- Every alternative considers the volume aspect, investments, incoming and outgoing payments.
- Two comparison slides, one showing the cash flow effect in numbers and one showing in graph form.

Abstract from Volvo group model is attached in Appendix A.

## 4.5 Description of the product cost

This diagram in the figure 16 below shows the different parts of the product cost. The different part of the product cost will be described in more detail in the text below and further in Appendix B and C.

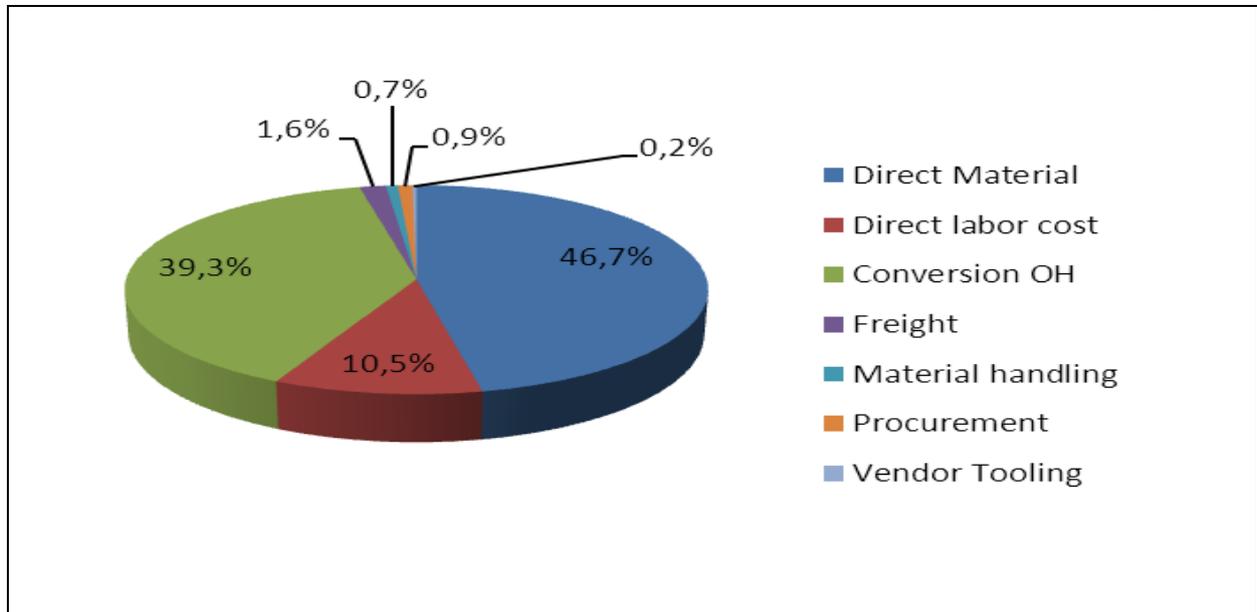


Figure 16. the different parts of the product cost.

### 4.5.1 Direct Material

Direct Material: Describes the direct material part of the product.

Direct labor cost: Describes the part direct labor in the product. The part of the product cost that consist of direct labor.

### 4.5.2 Conversion Overhead cost

Conversion Overhead cost: Describes in the example both the variable and fixed conversion cost in the product. This example from a product manufactured in Eskilstuna consists of 56% fixed and 44% variable cost. The fixed costs are mainly depreciation and interests for the machine park in the plant. In that part of the product cost lies also cost for white collar employees.

In the variable part of the Conversion Overhead cost lies costs for consumable supplies, maintenance, scrapping and salary cost for blue collar employees.

- Freight: Incoming freight cost for the product. Is a percent based on the purchased material
- Material handling: Examples are fork lifts cost, blue collar salary and emballage cost. Is a percent based on the purchased material
- Procurement: Is salaries for the purchasing organization who procuring the direct material. Is a percent based on the purchased material
- Vendor Tooling: Consists of depreciations and interests for the machine park that the company owns but is located at our suppliers. Is a percent based on the purchased material



## **4.7 Interviews**

To increase knowledge about the topic three interviews were performed with experienced people.

### **4.7.1 Interview Allan Carlsson**

The first interview was with Allan Carlsson, Finance Manager Operations Arvika, with 45 years of experience within the industry business and from several management positions in finance for Wheel Loaders and Articulated Haulers at Volvo Construction Equipment.

After describing the suggestion of process Allan indicated that if you can show potential savings in an early stage of the project you will be able to signal in opposite direction of the process and control or suggest the technology department to use a concept that will give best effect on the product cost. In a normal scenario the technology department will design the product and production and purchasing implements chosen concept in form of adapting the production system with investments, constructions and education. Purchasing department adapts the stream of material and supplier relations to the concept.

Regarding calculations the best way to allocate cost to right type of product is by activity based costing. VCE are not using ABC calculation, however VCE Arvika plant are using a similar allocation of cost. The plant uses hourly rates on cost centers where the plant allocates their fixed costs e.g. renting cost for buildings by the square meter in percentage the department are using. Another example of allocating fixed cost is the production engineering department where the cost for the technicians working with tasks regarding Welding and Machining are allocated to the products lifting frames and back and rear frames.

“The purpose of ABC calculations is to achieve knowledge about which products that is most profitable for the company”.

### **4.7.2 Interview Mats Lilja**

The second interview was with Mats Lilja, Business Controller and Acting Finance Manager at Danfoss Heatpumps. He has several years of experience from the Danfoss Group and from IBM in Austria.

The discussion concerned the possibility of allocating cost with current methods. Danfoss only allocates it's variable cost today and have one fixed hourly rate in there assembly line. The routing time varies among the products. The fixed part of the product cost is added in the inventory report. Since Danfoss Heatpumps only have assembly of roughly 4 hours for their products, the company sees no need of allocating its fixed cost during the manufacturing process.

To allocate the total cost of a product, to really see the operating margin on one product, that to see which products that are most profitable for the company, Mats suggests an Activity Based Costing Analysis or using a business case model process.

### **4.7.3 Interview Lars Lewin**

The third interview was with Lars Lewin, CFO and Vice President Operations Europe. Operation Europe is the biggest part of Operations within Volvo CE.

Lars mention activity based costing as a method to identify cost drivers. He also mentions that when it comes product cost calculation there is no certain method that Volvo always uses. New design may demand new calculation method. “The method shall be adapted for the purpose”.

The hardest thing when it comes to estimation of product cost is the volume aspect. Base the volume aspect on a long range forecast with a sensitivity analysis.

Business case is the only way to prioritize scenarios. “The way of make money is to focus on the cash flow”.

## **5. Discussion**

### ***5.1 Stage-Gate Product development process***

The theoretical five stage-gate model from Cooper is a little bit less complicated than Volvo's global product development process model, the GDP. However, the different stages in Volvo's model are in many cases very formal and not very practical. What I like and think correlates is the business case stage which occurs in Cooper's model in stage 2 and in Volvo's model between pre-study and concept study. The difficulties by calculating a business case is to reflect on the business opportunities in a very early stage with a lot of uncertain data to reflect on.

### ***5.2 Lean Product development***

The reflection is that Volvo has developed the theory even further. Volvo is and shall be one of the companies that leads the development within Lean Product development. Another reflection is the use and focus on cross functional resources in the early and in the different stages of the process. What I especially like with the Volvo model is the focus on eliminating concepts. In that way you shrink the possibilities during the process down to one final solution.

### ***5.3 Product Platforms***

The thing I like with Volvo's model and focus that correlates with theory is the focus on commonalities. The CAST initiative is not really a commonality focus but the economics of scale focus is there. Use similar articles, components, fixtures and machines in as many products as possible. In that way you create a competitive product cost for a range of products and in that way sustain good profitability for the company.

### ***5.4 Business case model***

The business case model setup that Volvo Construction Equipment and the rest of the Volvo group use is complicated, old and not very tolerant to operational errors. However, it shows and focuses on the cash flow and the activities that have a positive effect on the business like Schaltegger e.g. mention. The description of cash flow from Bennet shows also a correlation with the model when it comes to inventory consideration. The conclusion is that both the theory and my interviews show that a business case is a vital tool to secure profitability for a business. There are potential improvements to do for Volvo with current business case model.

### ***5.5 Description of the product cost***

The reflection when it comes to product cost is that Volvo Construction Equipment is competitive when it comes to calculations. Volvo uses a qualitative full-cost system which includes fixed costs. Fixed cost is vital to use since many of our components for example axles and transmissions have a lot of fixed cost allocated in form of depreciation and interest. Activity based costing technique is the best method to create the most accurate product cost which my interviews confirm. The method is however too time consuming and Volvo does not use it for that reason. Volvo allocates the overhead costs by produced hours per value added area. A very productive area that creates a lot of program hours will absorb a lot of overhead costs in the business.

## ***5.6 Current situation product cost for concept choice in project NTP and CAST***

After studying some theories both from Volvo and others I realized that this is an area that the company has potential for improvements. Volvo Construction Equipment lacks a clear product cost estimation model suitable for some of the earliest gates in the product development process. I have therefore added a qualitative product cost estimation model to the CAST project, see chapter 6. The model is now used in the project with the CAST frame in Arvika production plant and been approved by the CFO and vice president of Operations Europe.

## ***5.7 Summary***

The general reflection is that Volvo in many situations handles its problems in ways that correlates with the theories that exists. In the situations that Volvo does not consider the theories the company really has reasons not to. In other areas Volvo shall lead the development and contribute to new research that will add more sustainable theory. My interviews confirm that a competitive product cost and a decent business case secure incitements to good business decisions in the future.

## 6. Result - Customized calculation example CAST Frames

As a result of the identified opportunity for improvement in early product cost calculations at Volvo CE, together with my theoretical and empirical experiences, this chapter now focus to come up with a suggestion for an improved solution. To do so in an as realistic context as possible, I tried my thoughts in a sharp product development project at Volvo CE in Arvika. The case project is called CAST and is a platform project for some products. CAST stands for Common Architecture Shared Technology and is a modular platform design philosophy used at the company based on standardized fabrication and assembly processes.

The results from my work in this CAST project with creation of an improved solution can be seen as the product cost model below in figure 17.

|   | Value added       | Current situation | Machine park end of sep | New invest allocated       | Machine park after Cast implementation %                  | Dep and interest part of product cost |                      |
|---|-------------------|-------------------|-------------------------|----------------------------|---|---------------------------------------|----------------------|
| <b>Operations</b>                             | <b>Routing</b>    | <b>current</b>    |                         |                            |   |                                       |                      |
| Svets delkomplett                             | 10                | 13 536,83         | 1 149 721               | 39 600 000                 |   |                                       | 9,81omkostnader      |
| Bearbetning delkomplett                       | 10                | 14 642,40         | 12 947 923              |                            |   |                                       |                      |
| Häft komplett ram                             | 10                | 11 154,05         | 5 173 706               |                            |   |                                       |                      |
| Svets robot komplett ram                      | 10                | 10 339,00         | 3 173                   |                            |   |                                       |                      |
| Slutsvets komplett ram                        | 12                | 14 007,71         | 446 429                 |                            |   |                                       |                      |
|   | <b>52</b>         | <b>63 679,99</b>  | <b>1 200 000</b>        |                            | 40 800 3300<br>000 %                                      | 25,00%<br>%                           | 825,00<br>%<br>eller |
| average hourly rate                           | 1224,61<br>5      |                   | <b>Försviner</b>        |                            |   |                                       | 525 360<br>12,00%T   |
| <b>Product cost development</b>               |                   |                   | <b>Delta</b>            |                            | <b>Assumptions</b>  |                                       |                      |
| Direct Material                               |                   | 73 913            | 7 912,74                |                            | DoE operations unchanged, + Direct material from 16820731 |                                       |                      |
| DL + Conversion Cost                          |                   | 589 040           | 517 739,91              |                            |   |                                       |                      |
| MO  |                   | 85 556            | 84 559,57               |                            | Based on new Direct Material cost                         |                                       |                      |
| <b>Total</b>                                  |                   | <b>748 509</b>    | <b>610 212,22</b>       | 441,23%                    |   |                                       |                      |
| Bakram bef L60 70 90 G std cost 2013 16820731 |                   |                   |                         |                            |   |                                       |                      |
| <b>Name of Cost Comp.</b>                     | <b>Overall</b>    | <b>value add</b>  | <b>hours</b>            | <b>average hourly rate</b> |   |                                       |                      |
| Direct Material                               | 66 000,00         |                   |                         |                            |   |                                       |                      |
| Direct labor cost                             | 55 555,00         |                   |                         |                            |   |                                       |                      |
| Conversion OH                                 | 15 744,97         |                   |                         |                            |   |                                       |                      |
| Freight                                       | 396,60            |                   |                         |                            |   |                                       |                      |
| Material handling                             | 265,81            |                   |                         |                            |   |                                       |                      |
| Procurement                                   | 252,68            |                   |                         |                            |   |                                       |                      |
| Vendor Tooling                                | 81,37             |                   |                         |                            |   |                                       |                      |
| <b>Total</b>                                  | <b>138 296,43</b> | <b>71 299,97</b>  | <b>16,70</b>            | <b>4269,322<br/>94</b>     |   |                                       |                      |

Figure 18. Product cost model for the CAST project

This model above is created based on a qualitative cost estimation technique. When it's comes to value added calculation I have based the calculation on current product routing with some adjustments based on the production engineering department estimations.

The principle is however routing time multiplied with hourly rates. The effect of capital cost in form of investments for the project is implemented by adding a percent increase comparing the current situation and value. The percent increase of the value of the machine park is multiplied with the depreciation and interest part of the value added part of the product cost. In that way you see the effect on the product cost when investing in a new machine park. The assumptions are unchanged volumes meaning fixed hourly rates. What the customer wants, in this case the Technology department, is the effect on the product cost when implementing CAST. One major aspect of the project is cost efficiency. This model is created after this demand or purpose. I find this a good example on what our CFO is meaning in the interview with a calculation method created for a purpose, in this case product cost estimation.

To take good and accurate business decisions a sustainable and detailed cost calculation method is necessary. In project cost calculations with a new value add process it is especially important to estimate routing hours in an accurate way. The hourly rate is easy made by a qualitative cost analyze technique. The example is using existing current hourly rate for a

similar process area. The other aspect of project cost calculations is the consideration of the investments. Which level of capital expenditure is necessary and how does it affect the product cost.

Along with an accurate cost calculation a business case shall be the fundament for the decision when launching a new product or business. The business case is focusing on the cash flow not considering depreciation and calculated interest like the product cost calculation. Instead the business case setup considers the cash flow of the investment that in a later stage creates the cost for depreciation and interest.

## 7. Conclusions

### *7.1 Objective of this research project and research questions.*

#### 7.1.1 Objective

As previously stated in chapter 1 the objective of this research project was to,

Create suitable financial model that can be used when choosing a concept in early stages in the product development process to secure highest possible profit for Volvo Construction Equipment.

To fulfil this objective three research questions were identified. Theoretical as well as empirical studies have been used to find the answer to those questions. The studies have resulted in the proposed framework, described in chapter 6.

#### 7.1.2 Research question 1

What are suitable business models today?

The theoretical chapter three together with chapter four empirical studies gave me an understanding to answer research question number one. Suitable business models shall basically focus one single thing, cash flow. Solid liquidity management is vital for all kinds of businesses. Cash flow has a direct connection to the liquidity in a business. If you make your decisions based on best possible cash flow your company will increase its profitability. The CFO of Volvo Construction Equipment Operations Europe most important tool when it comes to important decisions is a well prepared business case model. Sweden's biggest company, the Volvo group, uses a little bit complicated model. Still it is usable when you are able to understand all parts of it. The reflection of the theory is that it is hard to find good models. If that depends on lack of models or bad research is hard to tell.

#### 7.1.3 Research question 2

How should allocation of overhead and fixed costs in a product cost calculation scenario work today?

The reflection when it comes to allocating fixed and overhead cost in the product cost today is really depending on what need and demand the company has of that data. The conclusion comes after studying the activity-based costing theory in chapter three and reflect the collected data from the interviews. Smaller businesses like Danfoss do not allocate the fixed cost to the product at all. Volvo allocates its fixed cost in more or less sophisticated ways not putting too

much effort on investigate where the cost belongs. In that way you never get a really accurate product cost calculation. The conclusion of that is that it makes it harder to see which products that have the best margins and earn the most money on in the business. Bad or no allocation of fixed and overhead costs complicates business decisions and may affect the profitability for the company in the long run.

Today the Volvo group allocates its fixed and conversion cost based mainly on production hours and the support functions e.g. production engineering customers. The department with an hourly rate will absorb the support functions cost in the business. The reason for not doing a deeper analysis of the fixed cost is that it is too time consuming.

A suggestion for improving the process in the future is to adapt an activity based costing model thru a business intelligence solution with some fixed parameters. That will ease up the calculation process and will give more time for analyzing the calculation and margin for the product.

### **7.1.4 Research question 3**

|   |
|---|
| How can a financial model support early decisions in a product development project? |
|---|

A financial model that accomplishes to answer for all the necessary criteria's within a product development project is almost a guaranty for reaching its financial targets. The better data you can provide a model in an early stage the better output you get. Many product development models, like Coopers in chapter three, supports the construction of a business case in very early stages of a project. If you can provide good information or estimations of for example supplier contract, drawings, operational routings and potential investments when choosing a scenario you will be able create consistent product cost estimation (business model). Product cost is an important part of every development project. Can you have a good estimation in early stages it eases up the other stages and the progress of the entire project.

The qualitative technique for product cost calculation that I created and uses in the result chapter supports the CAST projects for products to Wheel Loaders. It is based on all the criteria's mentioned above. To secure the models credibility before presenting it for the project I consulted with the CFO of Operations Europe which agreed using it.

## ***7.2 Industrial and academic relevance***

Based on the theoretical and empirical collected data in this thesis I can say that Volvo Construction Equipment applies a lot of the processes described in the theories. One example is the Qualitative cost estimation technique described by Niazi among others. Volvo is looking a lot on similarities when it's comes to costing new products.

Qualitative cost estimation techniques are primarily based on a comparison analysis of a new product with the products that have been manufactured previously in order to identify the similarities in the new one. In general qualitative techniques help to obtain rough estimates during the design conceptualization

## ***7.3 Future research***

In general Volvo Construction Equipment needs to be more aware of the product cost. There are several initiatives in form of cost reduction projects, gross margin councils and focus from the Technology department to focus on product cost. However the knowledge and awareness of how to calculate and what effect actions have on the product cost needs to improve in general at the company before any significant change and improvement will occur. More research from people with financial background is therefore to recommend for closing the knowledge gap in Volvo Construction Equipment.

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# Appendix A

## AB Volvo Business case model

**Investment Profitability calculation**  
AB Volvo – Business Control

**Information**

- Enter negative amounts (minus sign) for Capital outlay
- Enter amounts in Millions (Mio.€)
- Enter figures in yellow/grey areas (Alternative 1,3)
- The model assumes that all payments occurs at the end of each year
- For further information regarding Investments and Investment profitability calculations, see Financial Pol

**Setup**

Business Area: Volvo Construction Equipment

Country: SWEDEN

Volvo Group Capital Cost: 12.0%

Discount rate for NPV: 12.0%

Currency: SEK

Calculations Period: 10 years

Prices:  Fixed prices  Nominal values

Volvo Group Capital Cost issued: 2011-01-21  
Profitability calc. template issued: 2009-03-30

**Description**

Profitability Calculation: New transmission platform

Alternative 1: Scenario 1

Alternative 2: Scenario 2

Alternative 3: Scenario 3

**Alternative 1 - New transmission platform - Scenario 1**

Investment (outgoing payments) (Mio.€) NPV: 17, MIRR: 27%, IRR: 30%, Payback: 5.8

|                                       | Year 0      | Year 1      | Year 2      | Year 3      | Year 4      | Year 5      | Year 6      | Year 7      | Year 8      | Year 9      | Year 10     |
|---------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Investment (outgoing payments)        | -10.0       | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Change in Working Capital (cash flow) | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Others incoming payments              | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Others outgoing payments              | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Residual value                        | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Estimated operating income effect     | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| <b>Net Present Value</b>              | <b>17.0</b> |             |             |             |             |             |             |             |             |             |             |
| <b>Accumulated NPV</b>                | <b>17.0</b> |
| <b>Accumulated NPV</b>                | <b>17.0</b> |

Front slide

Alternative 2

**Alternative 3 - New transmission platform - Scenario 3**

Investment (outgoing payments) (Mio.€) NPV: 50, MIRR: 37%, IRR: 43%, Payback: 6.8

|                                       | Year 0      | Year 1      | Year 2      | Year 3      | Year 4      | Year 5      | Year 6      | Year 7      | Year 8      | Year 9      | Year 10     |
|---------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Investment (outgoing payments)        | -10.0       | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Change in Working Capital (cash flow) | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Others incoming payments              | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Others outgoing payments              | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Residual value                        | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Estimated operating income effect     | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| <b>Net Present Value</b>              | <b>50.0</b> |             |             |             |             |             |             |             |             |             |             |
| <b>Accumulated NPV</b>                | <b>50.0</b> |
| <b>Accumulated NPV</b>                | <b>50.0</b> |

**Alternative 2 vs Alternative 1 - Scenario 2 vs Scenario 1**

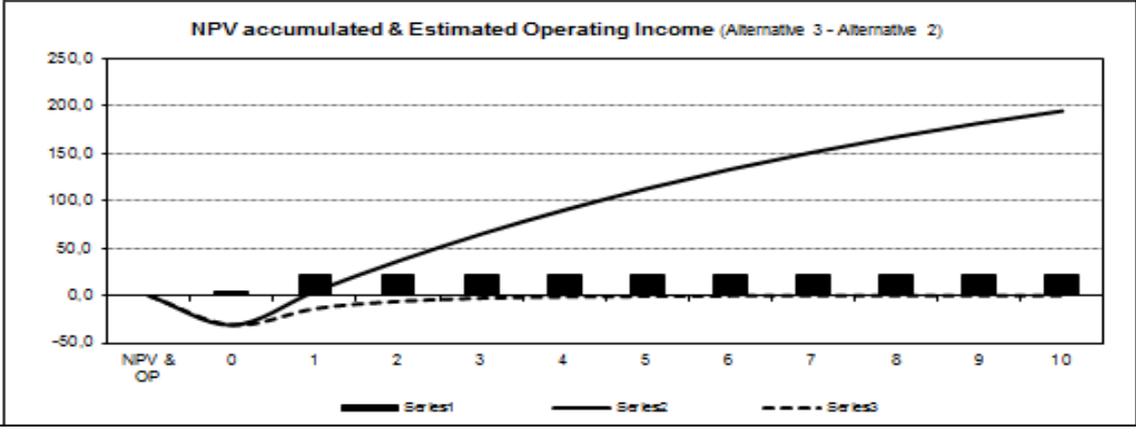
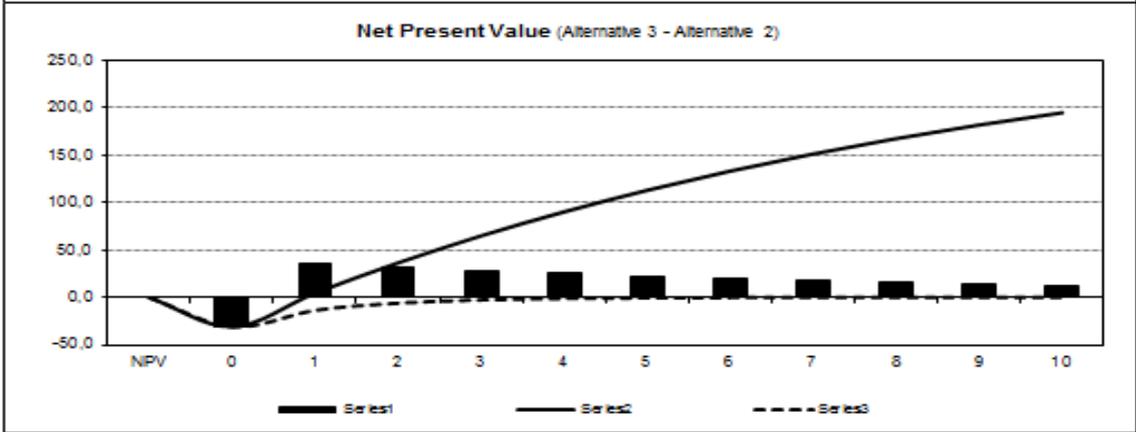
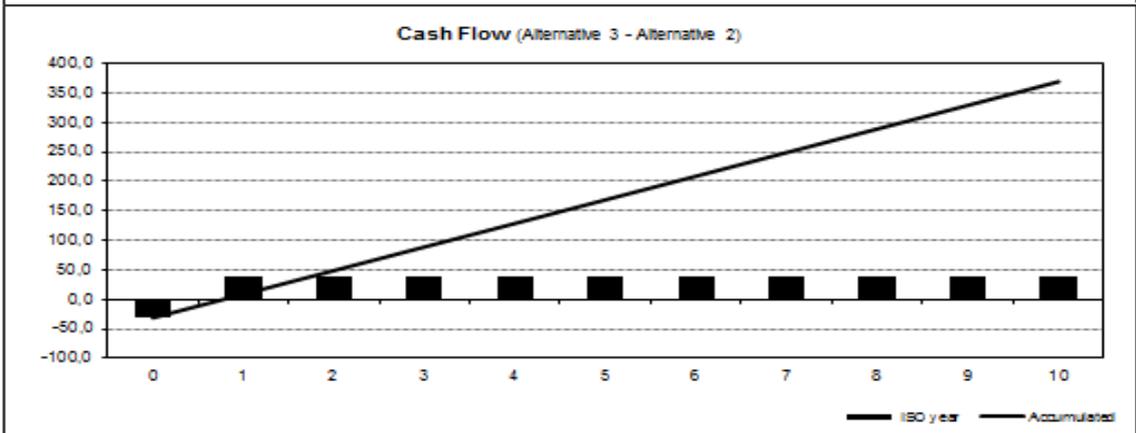
Investment (outgoing payments) (Mio.€) NPV: 93, MIRR: 40%, IRR: 46%, Payback: 6.8

|                                       | Year 0      | Year 1      | Year 2      | Year 3      | Year 4      | Year 5      | Year 6      | Year 7      | Year 8      | Year 9      | Year 10     |
|---------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Investment (outgoing payments)        | -10.0       | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Change in Working Capital (cash flow) | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Others incoming payments              | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Others outgoing payments              | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Residual value                        | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| Estimated operating income effect     | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| <b>Net Present Value</b>              | <b>93.0</b> |             |             |             |             |             |             |             |             |             |             |
| <b>Accumulated NPV</b>                | <b>93.0</b> |
| <b>Accumulated NPV</b>                | <b>93.0</b> |

Alternative 3

Comparison

| Alternative 3 vs Alternative 2 - Scenario 3 vs Scenario 2 |       | Valve Construction Equipment, SWEDEN, SEK, 10 years, Fixed Prices, MLOC |              |
|---|-------|---|--------------|
| Discount rate for NPV:                                    | 12,0% | Valve Group Capital Cost:   | 12,0%        |
|   |       | <b>NPV</b>  | <b>195</b>   |
|   |       | <b>MIRR</b>   | <b>37%</b>   |
|   |       | <b>IRR</b>  | <b>129%</b>  |
|   |       | <b>Payback</b>  | <b>-29,2</b> |



Graphs

## **Appendix B**

***According to Volvo Financial Policies and Procedures 2011 the definition of the cost categories are:***

### **Direct materials**

#### **Contents**

Raw material, parts and components purchased from suppliers outside the Volvo group.

#### **Allocation method:**

Directly traced to products.

### **Direct labor**

#### **Contents**

Cost per man-hour, including social expenses.

#### **Allocation method**

Directly traced to products.

Resources directly consumed by the product, i.e. direct materials and direct labour.

### **Conversion overhead cost**

#### **Contents**

- Salaries and wages, including social expenses, etc
- Company cars for employees and others
- Training
- Other personnel expenses
- Purchased services, both internal and external.
- Calculated interest on total inventory.
- Operational maintenance of property, plant and equipment
- Travel expenses
- Containers
- Energy
- Rejections, scrapping
- Consumables
- Hand-tools and consumable tools
- Small equipment
- Maintenance of machinery

#### **Allocation method**

Attributed to products based on cost drivers to the greatest possible extent, otherwise allocated.

### **Incoming material shipping costs**

#### **Contents**

Freight, insurance and customs duty.

#### **Allocation method**

Attributed to products based on a cost driver. In certain cases directly traced to products.

## **Incoming material handling costs**

### **Contents**

Costs for handling of incoming goods up to the point where the conversion process starts.

### **Allocation method**

Directly traced to products or attributed to products based on a cost driver.

## **Procurement costs**

### **Contents**

Costs of the purchasing department. Possible other costs in connection with the procurement of material.

### **Allocation method**

Attributed to products based on a cost driver.

## **Vendor tool costs**

### **Contents**

Costs for Volvo owned tools placed at suppliers. Include calculated interest and historical cost depreciation.

### **Allocation method**

Directly traced to products.

## **Appendix C**

***According to Volvo Financial Policies and Procedures 2011 the definition of fixed and variable cost is:***

### **Fixed/variable costs**

The definitions of fixed/variable as per the below are to be used solely for the purpose of the productivity calculation and for determining the short-term result effects of volume fluctuations. For product costing, the definition of fixed/variable as per the FPP Chapter C3 must be used.

### **Fixed costs**

For the purpose of the productivity calculation the following costs are considered as being fixed. The main criteria has been a consideration of whether or not the cost type can be regarded as being volume driven:

- Capital costs (depreciation and calculated interest on fixed assets)
- Renting or leasing of assets
- Property insurance and taxes
- Maintenance cost for buildings
- Monthly salaries (white collar)
- Company cars contracted
- Media supplies (electricity, water, compressed air, etc)
- IS/IT costs
- Rented services (contracted, e.g. VBS costs)
- Sold services (white collar salaries)

### **Variable costs**

All other costs are regarded as being variable. This means that, for the sake of simplicity, all blue collars (both direct and indirect) within the production process, with the exception of building maintenance, are regarded as being volume-driven and therefore a variable cost.

Allocation methods in the product cost calculation

The various cost items are allocated to the products according to one of the following Methods:

#### **Direct tracing**

Resources directly consumed by the product, i.e. direct materials and direct labor.

#### **Attribution**

Resources consumed by a cost driver that can be related to the product. Example: purchasing costs linked to the number of parts used in the product can be attributed to the product. Activity based costing (ABC) is recommended where applicable.

**Allocation**

Resources consumed in producing the products which should be included in the product cost but which cannot be traced or attributed need to be fairly allocated to the products. Example: production maintenance costs could be allocated on the basis of machine hours.

**Fixed and variable cost split of conversion costs**

In the product cost calculation a distinction is made between:

- Costs that should be split on the production volume in the calculation period (variable in this sense).
- Costs that should be split on average volume over a longer period (fixed).

All capital costs (see Section 8.11 below) are considered fixed. All conversion costs other than capital costs and related costs are considered variable, even if some variable costs are not 100 % flexible to volume on a short-term basis.

Annual planning and decision-making would use the fixed/variable split in line with the product cost calculation. Longer term planning would regard all cost as variable over that longer time period.

## **Appendix D**

### ***Questions in Interviews***

Which allocation method of cost do you prefer? Can you give examples?

When it comes to projects, how do you think the calculation/estimation of product cost shall be calculated in an early stage?

Do you think a business case is a good way to prioritize when choosing scenario in a major project?

What do you think Volvo can improve when it comes to product cost calculations/estimations in major projects?

What is the limit for allocating fixed cost? Always? If possible?