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1 Objectives

Increased competition and vocal customers have made it imperative that every company should upgrade its processes constantly to stay ahead of the competition. This is achieved mainly through design and process designs and cost reductions. The process of actual designing is product-dependent and it is more important to identify the aspects of products that require designing than the process of designing. Target costing is a strategic tool for planning that takes a holistic view of products and their sub-assemblies and identifies the opportunities for cost reduction and product improvement. Target costing also uses various techniques to set and achieve the goals based on the strategic plans of a company.

The objective of the current report is to describe the process of target costing for total product re-designing. This is achieved through the following steps.

- The concept of target costing is explained along with the various tools that are used. The managerial aspects that need to be considered are mentioned. The concepts of designing and cost reduction are also considered in the process.
- The introduction of the D10 tractor by Caterpillar during the late 1970s is analyzed retroactively with the help of target costing.

2 Introduction to Target Costing

2.1 Background

The most important feature of any company is its ability to stay ahead of the competition. In the midst of a plethora of products and choices for the customer, it becomes increasingly important for any company to make its products better, faster, cheaper and more innovatively. Increasing the efficiency of products has the two aspects of cost and functionality attached to it. An efficient designing technique takes the cost and functionality aspects into consideration during the early stages of product design. Such an approach provides us with the chance to concentrate our design efforts on important features and at the same time reduce the costs incurred on less important features. Target costing is like a planning tool that helps us to identify the features to be improved and helps us in setting targets for designing and cost reduction. It is generally known that challenging goals lead to better performance than the general goal of doing ones best [3].

Frequent innovations characteristic of today's market have decreased the life of new or re-designed products and increased the costs of design. This made it essential for every company to analyze its product's feasibility and profit-making ability before launching expensive design and manufacturing teams. Costs through the life cycle of a product require more attention as the costs of recycling, distribution, etc., keep increasing. The following important features can be considered to summarize the market condition for the last two decades.

- Increased competition
- Increased costs of design
- Decreased product life
- Increased non-manufacturing costs
- Increased importance of customer needs and demands
- Less-forgiving customers

2.2 Core Concept of Target Costing

2.2.1 Definition

The core concept of target costing is very straightforward. It is based on the logic that a company should manufacture the products that yield the desired profit. If the product is not yielding the desired amount of profit, the design of the product should be changed to obtain the desired profit or the product should be abandoned. A comprehensive definition of target costing as given in [2] is mentioned below:

“The target costing process is a system of profit planning and cost management that is price led, customer focused, design centered, and cross functional. Target costing initiates cost management at the earliest stages of product development and applies it through out the product life cycle by actively involving the entire value chain.”

2.2.2 Process

Target costing process consists of two phases known as establishment phase and implementation phase. The establishment phase defines goals for product concepts based on strategic plans and the implementation phase achieves the set goals. The relation between target costing and product design is illustrated in Figure 1 [2].

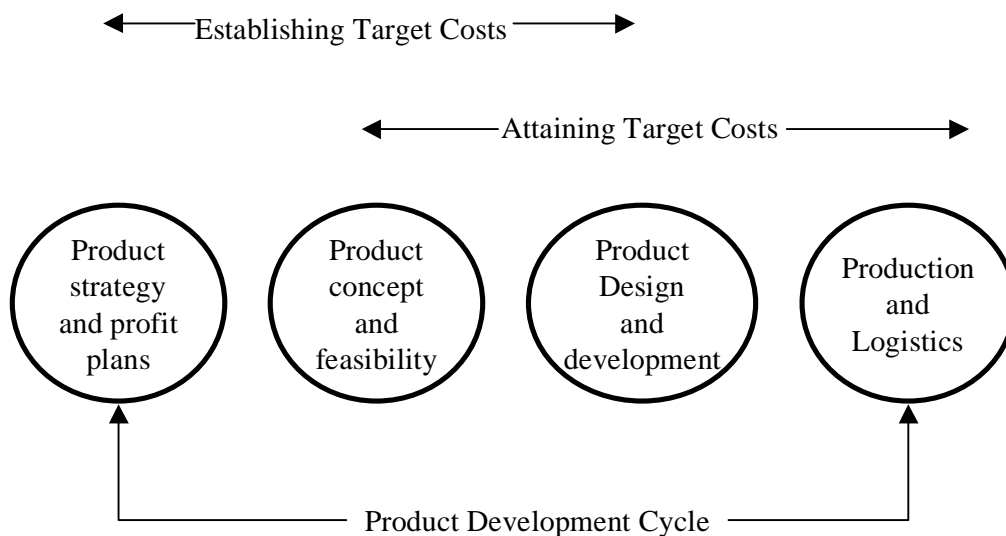


Figure 1: Target costing and product development cycle [2]

The process of target costing is illustrated in Figure 2 and is based on the cardinal rule, “If we cannot make the desired profit we should not launch the product.”

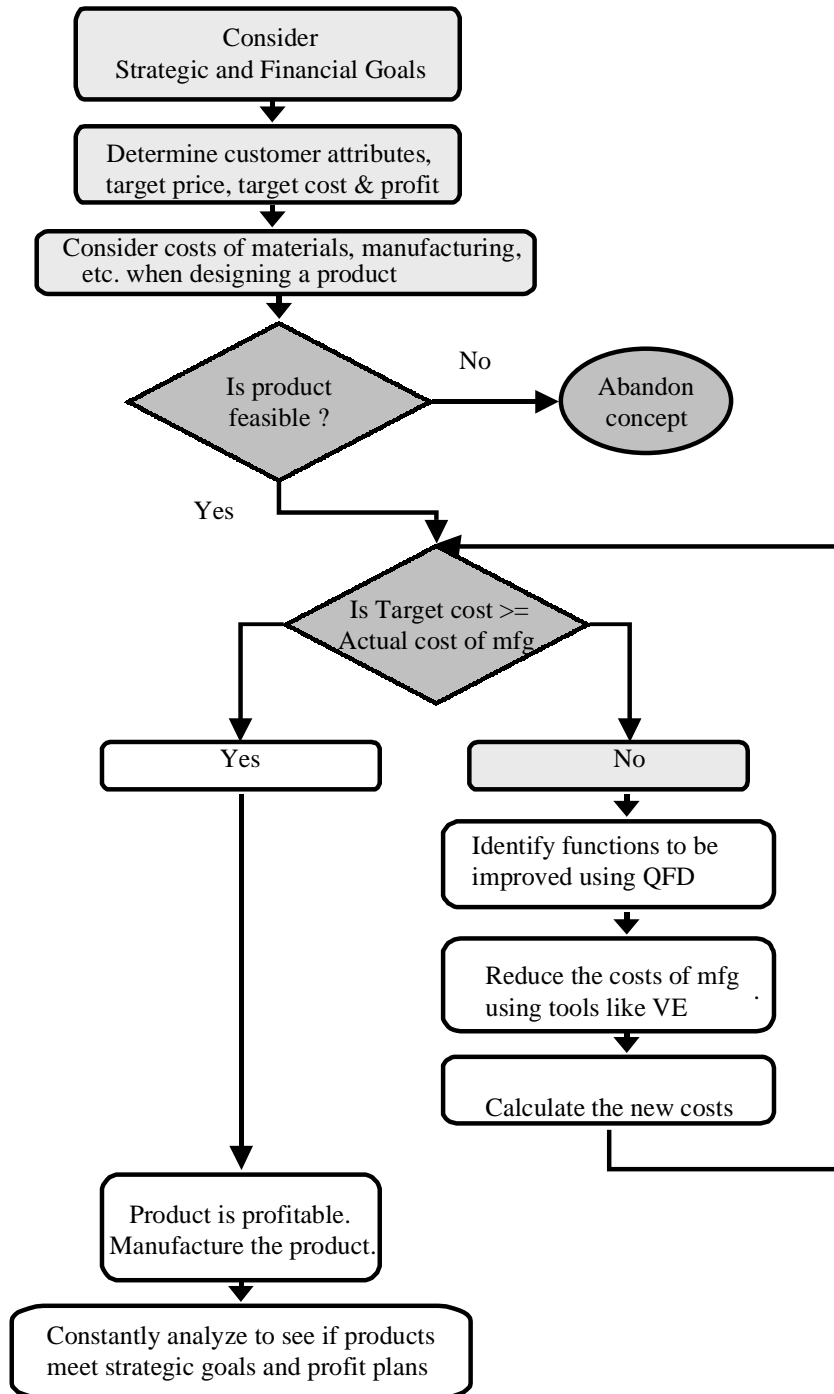


Figure 2: Target Costing Process

The illustrated process of target costing for product design (see Figure 2) can be described in the following steps:

1. *Consider strategic and financial goals:* Top management sets long-term goals for the complete corporation and every product should be designed to help the company to achieve these goals.
2. *Determine the customer attributes or demands:* This process involves conducting thorough market analysis and customer surveys to determine what the customer's needs and demands are for a given product.
3. *Consider costs and processes while designing:* This step must result in the design specification of the product. The major tools used to obtain the design specification of a product are (a) Pugh Method and (b) QFD.
4. *Determine the target price:* Target price is the price a customer is willing to pay for the new product. Thorough market analysis must be conducted to determine the target price.
5. *Determine the target cost:* Target cost, also known as the allowable manufacturing cost, is calculated by subtracting the profit required (ROS can be used to determine the profit required from the new product) from the target price.

$$\text{Target Cost} = \text{Target Price} - \text{Desired Profit}$$

6. *Determine the drifting cost and product feasibility:* Drifting cost, also known as the actual cost of manufacturing, is the present cost of manufacturing the new product and this is calculated with the help of the engineering department. It is also analyzed to see if all the desired functions can be provided in the new product. A good costing system like ABC (Activity Based Costing) will assist in determining accurate costs.
7. *Process Improvements:* If the designed product yields the required profit, the new product can be manufactured. If the new product does not yield the required profit, the product needs to be re-designed or the process of manufacturing should be improved to yield the required profit. Some tools like value engineering can be used to associate costs to components or functions in order to determine their cost efficiency. The components or functions that are cost inefficient should be re-

designed to reduce costs. If the products are found not to meet the financial profit requirements, they should be abandoned.

8. *Implementing / Evaluating long term effects*: It is essential to make sure that the new product will yield the required profits through its complete life and the product mix must be regularly adjusted to meet the strategic goals of the company.

2.3 Literature Review

The literature about target costing deals more with the concepts of target costing than with its practical application. Several companies where target costing is used are mentioned, but specific details about product designing and cost reduction are not available. Literature describing the concept of target costing and various techniques used in target costing, along with some important definitions of target costing are mentioned here.

The definitions of target costing are many, but they all focus on the same point of cost reduction. However, definitions vary in the scope of cost reduction. Some definitions take the overall product life cycle into consideration while some consider particular functions or just product development. Horvath and CAM-I take the product life into consideration and define target costing as follows [1]:

“Target costing is a set of management methods and tools used to drive the cost and activity goals in design and planning for new products, to supply a basis for control in the subsequent operations phase, and to ensure that those products reach given life cycle profitability targets.”

Target costing has been defined in [2] by listing all stages of product life cycle, while Cooper and Slagmulder [3] defined target costing in “Target Costing and Value Engineering” by placing emphasis on the aspects of cost, quality and functionality as follows:

“Target costing is a structured approach to determine the life cycle cost at which a proposed product with specified functionality and quality must be produced to generate the desired level of profitability over its life cycle when sold at its anticipated selling price.”

Different aspects of target costing including those of interest to management are detailed in [2]. The following are the key messages sent by target costing according to [2]:

- 1. Target costing takes place within the strategic planning and product development cycles of a firm. Product design goes through this development cycle in a recursive, rather than in a linear fashion.*
- 2. The first phase of target costing is the establishment phase. The focus here is on defining a product concept and setting allowable cost targets for a product or a family of products.*
- 3. The second phase of target costing is the attainment phase. This phase transforms the allowable target costs into achievable target costs.*
- 4. The establishment and attainment phases of target costing occur at different points in the product development cycle. Different organizational processes play primary and secondary roles in these two phases.*
- 5. Many other business processes support target costing, and the success of target costing depends on these other processes being performed effectively within an organization.*

The process of target costing is explained in detail in “Advanced Target Costing: State of the Art Review” [1] and “Target costing: The next frontier in Strategic Cost Management” [2]. The different steps of target costing and a guide for management have been laid out in [2]. These steps are detailed and used in the current report.

The Consortium for Advanced Manufacturing-International (CAM-I) made concerted efforts to promote target costing. Horvath and CAM-I [1] produced a comprehensive report detailing the basic technical concepts of target costing. CAM-I later worked with its core group to generate [2] to include all the aspects to be considered during the implementation of target costing.

The contribution of various techniques to target costing is different. Some techniques like the Pugh Method, Quality Function Deployment (QFD) and Value Engineering (VE) should be studied in more detail as these tools help in designing the products and processes. The Pugh Method helps in identifying customer requirements

and is explained by Stuart Pugh in [15]. This technique is used in the current report to identify customer attributes. QFD relates product functions to customer requirements in order to establish goals for product design. Bob King explains this method in [16]. QFD is used in the current report to correlate the customer attributes to components or product attributes to establish their relative importance. The candidates for improvement are the product attributes with high relative importance. Value engineering helps us in reducing costs incurred by a product and is detailed by Cooper and Slagmulder in [3]. This process is used to identify product attributes that are not cost efficient.

Horvath [1] describes target costing and relates it with Activity-Based Costing (ABC), product life cycle management costs, and Value Engineering. Target costing along with supporting tools, techniques and means of deployment is detailed in [2]. Cooper and Slagmulder [3] explain how value engineering can be used along with target costing to increase the value of a firm's products. Kaizen costing, the process of continuous cost reduction after a product is launched, is explained along with its relationship to target costing by Monden and Hamada in [7]. Effects of Return on Investment (ROI) and Return on Sales (ROS) on target costing are analyzed by Sakurai in "Measures of Organizational Improvement" [11].

Effect of target costing in many large companies like Nissan, Toyota, and NEC, are discussed in some papers. Sakurai [17] mentions the reasons for the use of target costing in Japan. He mentions that increased consumer demand for product variety and shortening of life cycle prompted Japanese industries to adopt target costing. Worthy [12] shows how target costing helped several industries in Japan. He mentions the way Japanese industries take calculated risks after using management techniques like target costing. Schmelze, Geier, and Buttross [13] show how target costing is applied at ITT Automotive and how it created cost savings before the product reached the production stage. Cooper and Chew [14] illustrate that target costing lets the customer and not the product set the price with reference to Olympus and Komatsu. Brausch demonstrates the implementation of target costing in the textile industry to reduce the costs before they are incurred [6].

The literature review of target costing shows us that the concept of target costing and the tools used for its implementation are described in detail. The companies that

have implemented target costing are multi-billion international companies, and the literature illustrating the use of it in small-scale industries is sparse. The current report explains target costing and discusses the issues of implementation from the perspective of a company by conducting a retroactive analysis of a real life decision taken by the Caterpillar Company in the late 70s. Caterpillar is currently an advanced and a large company, but the technological state of Caterpillar in the late 70s is assumed for purposes of the current report to be immature and equivalent to the state of current companies. Caterpillar currently implements target costing while most of the companies are not established enough to implement target costing.

2.4 Facts / Advantages of Target Costing

The major characteristics or advantages of target costing as mentioned in [1] are listed below.

- Target costing will provide management methods and analytical techniques for developing products and services whose costs support strategic objectives for market position and profit.
- Product costs will be defined from the customer's viewpoint; they will include functionality, cost of ownership and manner of delivery.
- Target costing is a critical component of product development teams and concurrent engineering.
- Target costing will incorporate as wide a range of costs and life cycle phases for the product or service as can be logically assigned and organizationally managed.
- Target costing will provide analytical techniques to indicate where cost reduction efforts on parts and processes will have most impact, and where commonality and simplification can be increased.
- The quality of cost data will be consistent with the responsiveness and level of detail required at various development phases: The system will use the logic and benefits of activity-based costing.
- The achievement of market-driven product attributes will be protected from cost reduction ambitions.
- Targets for product cost will be set for various life cycle phases in development and production.
- Target costing will aim for appropriate simplicity, relevance and ease of use by product development teams; it avoids unnecessary complexity of language and time consumption in cost assessments.

The process of target costing creates a team based, proactive atmosphere, where representatives from different departments get together to make decisions. This leads to a reduction in the information gap between different departments and makes the

departments more responsive as they realize the importance of their activities [2]. Another significant advantage of target costing is its inherent flexibility as mentioned by Sakurai [8]. He mentions that target costing was used by Atsugi to reduce the current level of standard costs by autonomous efforts, while Daihatsu Motor used target costing to establish a new plant to maximize profits through controlling costs by the use of automation and flexible manufacturing systems. These factors are some of the many reasons that establish target costing as a good technique.

2.5 Outline of Report

This report shows the implementation of target costing and analyzes the managerial aspects of target costing from the perspective of a manufacturing firm. The process and advantages of target costing have been presented in Chapter 2. Chapter 3 deals with the role of target costing in product re-designing to be competitive, and studies the aspects of implementation from the practitioner's view. Chapter 4 illustrates the re-designing process of a Caterpillar tractor in the late 70s using target costing. Chapter 5 conducts a sensitivity analysis on the case study in Chapter 4 to determine the most significant factors. Conclusions regarding target costing based on the case study are described in Chapter 6.

3 Role of Target Costing in Product Re-Designing

The implementation of target costing in large firms has been reported in many papers. The different aspects to be considered while implementing target costing in a firm are analyzed in the Section 3.1. The differences between large and small firms mainly exists in the setting up of target costing teams, marketing support, and functional departments.

3.1 Establishing Target Costing in the Company

The first and the most important step of target costing is the critical decision of management to implement target costing. The importance of this step cannot be overstated, as target costing is a dynamic process based on management's strategic plans. Some major reasons for implementing target costing can be increased competition, expansion of business, or introduction of new products.

Once the decision to implement target costing is taken, the target costing team needs to be established. Small manufacturing firms do not have the luxury of having multiple target costing teams for different phases or for different functions of a product. The effectiveness of target costing is usually expected to increase with an increase in the number of involved personnel. A target costing team has the advantages listed below:

- Association with the complete cycle of product development facilitates future revisions.
- No information gap occurs between different stages of product design or target costing.

The target costing team should consist of personnel from different functions and departments. It is very important to note that the members of the target costing team should not be completely dedicated to target costing. The personnel must still have significant functional responsibility, as this keeps them updated in their functional areas. The target costing team should consist of personnel from marketing, information systems, cost planning, operations, research and development and all functional areas. A top

management executive, who has a good knowledge of the company's strategic plans, must lead the target costing team. However, costing, production and designing are more important and the product designing process can be carried by frequent inputs from the remaining departments in a firm.

The members of a target costing team should be trained in target costing implementation. A complete proper working knowledge of target costing is necessary for its success. However, the most important factor is practice. Every firm is different from another and it is very important to start implementing target costing and it should be refined to meet the requirements.

For the successful implementation of target costing, the team should be provided with the information required for conducting the analysis. The type and the amount of data required vary depending on the type of the product, but typical categories of data required are mentioned below.

- Customer needs and demands
- Pricing data
- Costing data
- Information system to track and evaluate the target costs and manufacturing costs

For a firm without a big marketing department, there are several ways to collect the required data. Customer surveys can be used to gather information about what the customer currently needs. Operations personnel taking customer orders can collect valuable information about customer demands. It is very important to store customer demands historically as they can indicate trends in the market. The Internet and organizations like Equipment Manufacturers Institute (EMI), Engineering Information Inc., etc. can provide valuable historical information. Pricing data consists of the customer's willingness to pay, which can be determined from customer surveys.

The most efficient way to collect this pricing data is by function. Let us consider an eraser; the basic function of an eraser is to erase. But additional functions and features include softness, shape, scent, pen and pencil eraser in one, longevity, and color. Pricing data must indicate how much a customer is willing to pay for each function or feature.

An efficient method is to start from a current product and conduct surveys to identify the price paid for features based on customer surveys. Costing data should be obtained from the current costing system and cost bases for distributing administrative, design and marketing costs must be established. Last but not the least, systems and databases must be established so as to collect this information and the data must be very accessible to the target costing team.

The duration of the target costing project depends on the type of the product being studied. But, the preliminary analysis to reject or accept a product is suggested not to take more than a couple of months for a manufacturing firm. The total time for launching a product should be proportional to the product life.

3.2 Different Stages of Product Design

Implementation of target costing in a firm is achieved through the establishment phase and the implementation phase as mentioned before. These two phases happen within the four major phases of product design, which are [2]:

1. Product Strategy and Profit Planning
2. Product Concept and Feasibility
3. Product design and Development
4. Production and Logistics

The phases are classified based on critical decision points in product designing / redesigning rather than being based on time or function. The process and the decisions to be taken at the end of each step are explained in the Section 3.2.1.

Each phase corresponds to one or more steps illustrated in Figure 2. Product strategy and profit planning obviously includes the first step of setting strategic and financial goals. The second phase includes the next four steps of considering customer attributes and costs for designing the new product. It also includes determining target price, target cost and drifting cost for new concepts. This phase will validate the feasibility of various product concepts. The third phase involves process improvements based on the results of phase two and finalizes the design and manufacturing methods for the selected concept in phase two. Phase four involves implementing the manufacturing

processes and evaluating long term effects to make sure that the product helps in achieving the corporate goals. The association between the various phases and the steps in Figure 2 is illustrated in Figure 3.

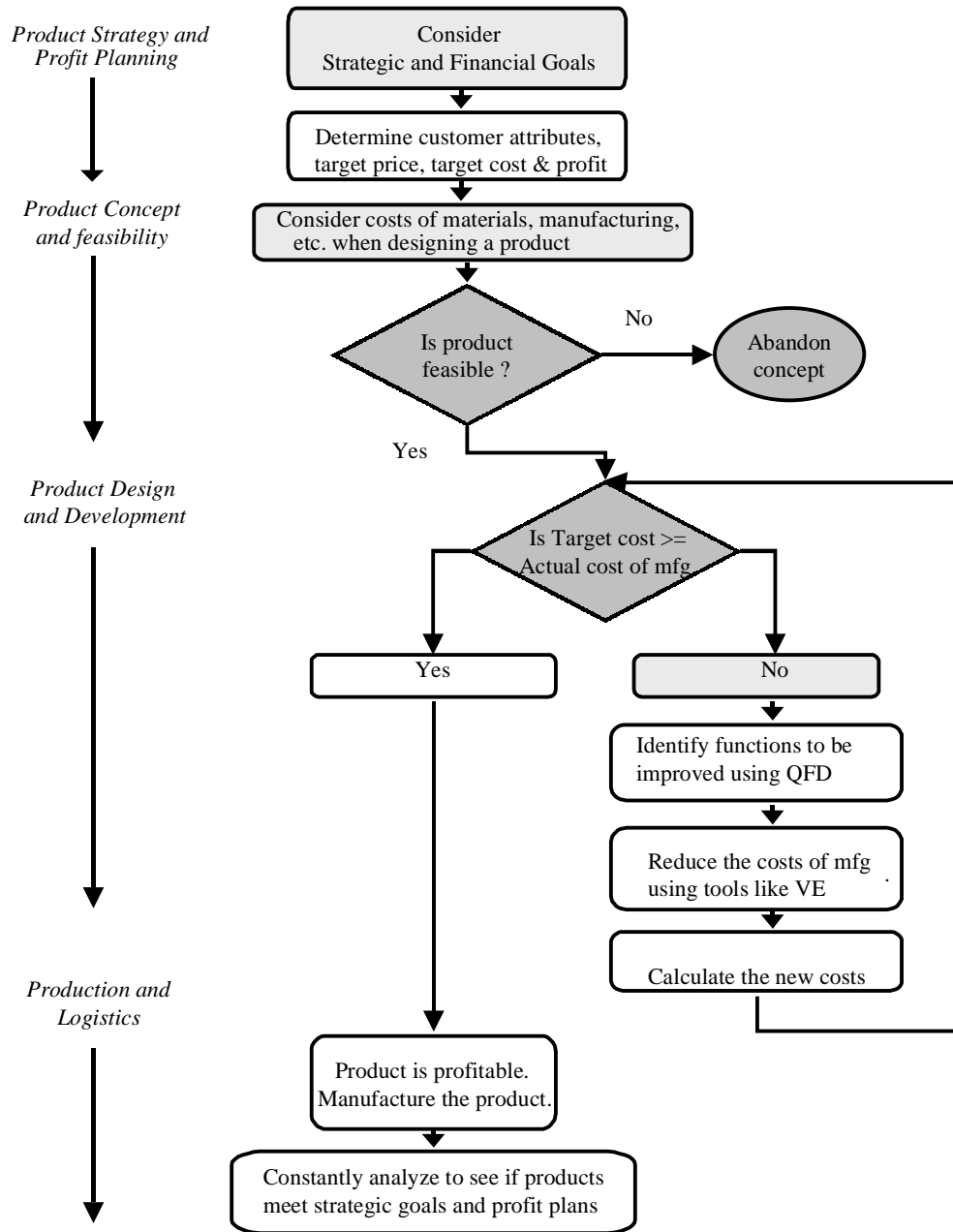


Figure 3: Target Costing Process along with Product Design phases

The various phases and the main tools used in each phase are illustrated in Table 1.

Table 1: Product design phases and tools used

<u>Various Phases</u>	<u>Tools Used</u>
Product Strategy and Profit Plan	<i>National Growth Indicators, Marketing Plans, etc.</i>
Product Concept and Feasibility	<i>Pugh Method, QFD, Preliminary cost analysis, etc.</i>
Product Design and Development	<i>QFD, Value Engineering, ABC, Process engineering, etc.</i>
Production and Implementation	<i>Value Engineering, ABC, Kaizen costing, etc.</i>

3.2.1 Product Strategy and Profit Planning

The objective of this step is to define long term strategies and goals of a firm. The strategic plan of a company must include the planned rate of return and market expansion plans. There is no fixed method for determining the desired rate of return. But it is indirectly determined by the expectations of stockholders and the price set by competitors.

Marketing information about the trends in customer demands must help us in establishing market expansion plans. Market expansion plans can include particular product definitions or a general description of the market to be reached. For example, an encapsulation firm for a pharmaceutical client can have market expansion for solid tablet manufacturing, packaging and distribution or to enter paint-ball manufacturing.

The type of marketing information required depends mainly on the position of the industry in a supply chain. Industries in the lower levels of the supply chain can obtain most of the information from their direct upper level customers. The interaction with suppliers is very important in large assembly industries and the supplier's strategic goals and profit margin calculations should coincide with ones own firm's strategic plans. For the previously cited example, the marketing information and strategic plans should consider the pharmaceutical clients supplying the material to be encapsulated along with the end user.

Established costing systems should provide the top management with the information required for setting strategic goals for profit margins. Long term planning needs to consider many factors and a few important ones are listed below:

- Financial
- Establishing new customers
- Increasing market reach
- Establishment of brand name

3.2.2 Product Concept and Feasibility

The objective of this step is to determine feasible product concepts. It is not essential to determine precisely the manufacturing process at this stage. But, this is the phase where several concepts are analyzed to determine the best concept.

The process of establishing product concept feasibility consists of the following steps:

1. Determining if the product meets customer demands
2. Establishing the method of manufacturing
3. Verifying that the product generates the desired profit margin

The product concepts are analyzed to determine if they at least satisfy the customer needs. A product concept is considered to meet the requirement if it satisfies the customer needs. The costs and manufacturability of concepts is later considered to determine the best concept. But, at this preliminary stage all concepts that satisfy the customer needs are considered.

The Pugh Method [15] focuses on the total life cycle of the product to determine the complete list of customer needs and wants for total design. The Pugh Method defines total design as *“a systematic activity, from the identification of the market/user, to the selling of the successful product to satisfy that need.”* The customer needs can be defined by analyzing the complete product life cycle, and the customer demands must be classified into needs and demands. It is important to apply the Pugh Method in the early phases to make sure that all customer requirements are considered. It is also important at this stage to determine the price a customer is willing to pay for each requirement/function (also known as target price of the requirement/function). The different aspects that need to be considered during designing according to the Pugh Method are listed in Table 2.

Table 2: Different aspects to be considered during product design [15]

a. Performance	b. Environment	c. Life in service(Performance)
d. Maintenance	e. Target Product Cost	f. Competition
g. Shipping	h. Quantity	i. Manufacturing facility
j. Size	k. Weight	l. Aesthetics
m. Materials	n. Product life span	o. Standards and Specs
p. Ergonomics	q. Customer preferences and prejudices	
r. Quality and Reliability	s. Shelf life	t. Processes
u. Time scale of Project	v. Testing	w. Safety
x. Company constraints and market constraints		
y. Patents, literature and product data		
z. Political, legal and social implications		

After establishing that a product concept meets customer requirements, its functions must be analyzed to verify their manufacturability. Personnel from all positions and departments should apply their functional knowledge to determine the manufacturability of products.

Once the manufacturability of a product concept is established, the target price should be established by adding the target prices of all functions. The financial feasibility of a product can be verified by using the equation mentioned in the Section 2.2.2.

$$\text{Target Cost} = \text{Target Price} - \text{Desired Profit}$$

The profit desired from a product is determined based on the strategic goals set by the top management. If the actual cost of manufacturing is less than the target cost, the product concept can be considered economically feasible. If the actual cost of manufacturing is greater than the target cost, the target costing team needs to decide if the manufacturing process can be improved to reduce the cost. The last step is to compare different product concepts to determine the best concept for further analysis.

A few other factors that need consideration for cost-effective design and decision-making are listed below:

1. Actual cost of manufacturing must include total life cycle costs, i.e. it must include costs of designing, marketing, recycling, distribution, etc.
2. Product concepts must be analyzed along with suppliers in order to ascertain their feasibility.
3. Trends in customer demands should be identified and considered during designing.

3.2.3 Product Design and Development

An established product concept is refined to include more functions and to reduce costs of manufacturing to achieve target costs. The final output of this step is a complete and comprehensive definition of the product along with the process of manufacturing.

Quality Function Deployment (QFD) uses various charts and helps the designer by establishing relative weights for various quality characteristics and customer demands. A QFD chart compares the left section of the chart with the top section and identifies strong, moderate and possible correlations. Processes are analyzed to see if additional customer wants can be provided without adding significant costs. It is very important to consider the features provided by competitors at this stage.

QFD (Quality Function Deployment), a process that originated in Japan, helps us in designing products efficiently. Bob King defined QFD in [16] as:

“Narrowly defined, QFD refers to the organization that makes the design improvement effort possible. Broadly defined, QFD also includes the charts that document the design process.”

QFD is explained in detail in [16] and the major QFD charts (or tables) taken into consideration are:

1. Quality-table relates customer’s demands to quality characteristics and compares our current performance to competitor’s performance. This helps the designer to come up with the initial plan of design [16].
2. Functions / Quality Characteristics table is used to identify functions of the product that might not be known to the customer [16] by establishing correlations between quality characteristics and the functions of a product.

Quality characteristics not correlated to any customer function should be replaced by appropriate functions to capture customer demands.

The next step after establishing designing goals is to achieve them. The actual process of designing depends on the product and is not considered in the current report. But, the process of cost reduction using value engineering is described in this report. The basic concept of value engineering is to determine candidates for cost reduction by primarily focusing on product functions and only secondarily on cost [3]. Value engineering compares the relative degree of importance of each component or function to the percentage of total cost the component or function takes. Dividing the percentage degree of importance by the percentage of cost for that component gives the value index for that component. A component/function with a value index of 1 or more is cost inefficient and needs to be made cost efficient. The method of cost reduction depends on the type of the product and the process of manufacturing. Some common cost reduction methods include conducting staffing analysis to reduce staffing levels, compromising the quality of a function in a product if it is not very important, decreasing the inventory level, improving yield, etc. This process must be continued so as to add value to important components and to reduce the costs of less important components until the target cost is reached.

If the actual cost of manufacturing exceeds target cost, the product concept should be discarded. This should not happen at this stage, as the second stage of product concept testing must determine if the target costs are achievable or not. But, if it ever happens, the target costing's cardinal rule must be followed and the product should not be launched except for marketing reasons.

Cost reduction can be achieved by identifying when and where the costs occur. Reference [2] allocates the total costs based on:

1. Value chain perspective
2. Life cycle perspective
3. Customer perspective
4. Engineering perspective
5. Accounting perspective

Each perspective provides a unique way of looking at the product and helps us to identify where excess costs occur and to reduce them. Cost reduction should start as soon as possible and should concentrate on functions that are easy to improve and further cost reduction must be achieved.

3.2.4 Production and Logistics

Actual production should not be started until the target cost is considered achievable. This is just the beginning of cost reduction and constant endeavors must be made to reduce costs as much as possible. Frequent customer surveys should be conducted to determine the changes in customer wants, and the products must be modified accordingly.

Kaizen Costing is the process of continuous cost reduction. Economies of scale, setup improvements, work methods, etc. must be analyzed to increase the productivity of the bottleneck operation. This will help us in increasing the throughput of the line without adding costs, thereby increasing the profit margin. Root cause analysis must be conducted to identify the reasons for downtime and idle time and process improvements must be made. A simple method of conducting root cause analysis is to conduct time studies identifying the amount of non-productive time. The total non-productive time can be classified into various categories like waiting time for operator, waiting time for work in process (WIP), waiting time for maintenance, setups, etc. The major causes can be further investigated for improvement. For further details about Kaizen Costing refer to [7] and [10].

It must be understood that target costing is not a one-time phenomenon and the product mix should be continually analyzed and changed to meet customer requirements and strategic goals.

4 Case Study

4.1 Objective of the Case Study

The objective of the case study is to apply target costing to a real life situation of product redesign. The analysis is conducted retroactively on the product redesigning of Caterpillar's D9 crawler tractor.

The current state of a manufacturing company not implementing target costing is assumed to be technically similar to the state of Caterpillar in the late 70s. No research has been conducted to establish this and this was merely assumed for the purpose of this report. The case study presented here, along with the process description in Section 3, should help manufacturers to further understand target costing.

Caterpillar is a manufacturer of tractors, earth moving equipment, etc. The largest crawler tractor manufactured by Caterpillar during the late 70s was the D9, and it did not meet the increasing demands of customers. This required Caterpillar to introduce an improved version of the D9, known as the D10. The improved D10 was a big success. This case study retroactively analyzes the design process of the D10 tractor model from the D9 model using target costing to determine the insights target costing could have provided to Caterpillar in the late 70s.

4.2 Introduction to Caterpillar

Joe Holt and Moe Best founded Caterpillar in 1925. Caterpillar is a 19.3 billion dollar company that manufactures tractors, earth moving equipment, etc. with 6.12 billion dollar sales in 1997 [34]. The company consisted of 50 manufacturing sites in 1977 [35] and had dealers located all over the world [34].

The world's first practical track-type tractor was introduced by the predecessor of Caterpillar in 1904. The Crawler tractor was born from this track type tractor due to the disadvantages associated with having a heavy tractor on wheels. Caterpillar is also the first company to offer mobile diesel power in a moving vehicle on a production basis in 1931. After World War II, Caterpillar expanded its operations outside America into Great Britain in 1950. From then onwards, having committed to quality and innovation,

Caterpillar increased its share in the world market of tractors and earth moving equipment [35] until the 70s.

In the late 70s, Caterpillar's product mix mainly consisted of crawler tractors, crawler loaders, wheel loaders, wheel dozers, hydraulic excavators, skidders and compactors. The total sales generated were about five billion dollars in 1976 [35] with an investment of \$ 187.9 million in research and engineering. Globalization of markets brought increased competition from foreign firms Fiat Allis and Komatsu, resulting in a decrease in the market share. At the same time competition in the domestic market from Detroit Diesel and Cummins Engine has increased. The requirement of earth moving equipment increased, as the customers wanted bigger and flexible tractors to increase their productivity and to decrease the lead times of projects and costs. Thus, the increased competition and customer requirements necessitated the re-designing of the D9.

4.3 Problem Statement

Product redesigning and development is a continuous process and this process started for D9 soon after its introduction in 1954 [29]. Some scaled up versions of the first D9 were manufactured for about a quarter century before the suspension system and drive train were re-designed to improve its performance.

The current report takes the goals established by the management and tries to redesign the D9 to compete with the competitors' products. The actual re-designing is considered outside the scope of the current report. But the report identifies the components that required redesigning and the components that require to be made cost efficient.

Target costing was used to lead a customer-focused pricing system in order to improve the current model of the D9. The data used for the analysis is obtained from Caterpillar Inc. [24] and Equipment Manufacturers Institute (EMI) [23]. Hypothetical estimates were made assuming myself as the customer where data is not available. Sensitivity analysis is done to identify the profit making ability of the redesigned product.

It is known that the demand for bigger tractors was growing in the late 70s. But, no great efforts were taken by the firms in 70s to identify this trend. A good reference for identifying market trends and to subsequently forecast product demand is [33].

Description of D9

The largest available D9 model before the introduction of D10 was D9H. The D9 had 410 hp and it used to weigh 50 tons. It is a track type crawler tractor with a rigid suspension, low sprocket, with track roller frames mounted on final drive case. [28].



Figure 4: Basic Caterpillar track-type tractor [37]

4.4 Applying Target Costing in Product Design

4.4.1 Product Strategy and Profit Planning

The objective of Caterpillar's re-designing effort is to increase its market share in the segment of heavy-duty tractors, especially in the category of tractors with more than 500 hp.

Rapid industrialization led to an increase in the demand for heavy earth-moving equipment and some of the specific reasons [28] are:

- The need for energy and raw materials is increasing all over the world as the resources that are available in the upper layers of earth's surface are becoming sparse and resources from more deeper layers need to be obtained.
- Ecological considerations also play a large part. The requirement to reclaim or return the land to its original state has substantially increased earth-moving needs.
- At the same time many projects such as dams and transportation systems require high-volume earth moving.

The process of setting strategic goals for the entire enterprise of Caterpillar Inc. is not considered here. But, the goals set in 1977 and mentioned by Naumann [35] at Chicago on March 17, 1977 are as follows.

- Increased capacity for diesel engines
- Increased capacity for large track-type machines
- Wheel loaders, lift trucks
- Growth in Brazil
- Maintaining the tradition of Enterprise and Integrity

Tracking down on the second strategic goal for increased capacity for large track-type machines, it is important to have innovative new products to beat the competition. The goals set by Caterpillar [28] for the new large track-type machines are as follows:

- Achieve a superior level of productivity over today's tractors.
- Design all major power train components into models for quick exchange.
- Reduce routine maintenance to keep the tractor working for a greater amount of its life.
- Improve operator ergonomics by markedly improving tractor ride characteristics, visibility and tool controllability.
- Assure that a tractor of this size could be transported and readily made operational at the job site.

Profit margins desired by Caterpillar from the re-designed product, the D10, are assumed to be 20% based on sales.

4.4.2 Product Concept Development and Feasibility

As mentioned earlier, this section selects the best feasible product concept from various alternatives, if available. In the current case study, new product concepts that satisfy customer requirements are not considered. Instead the current product is analyzed for re-design to meet customer requirements.

The preliminary list of customer requirements can be obtained by analyzing the life of the product using the Pugh Method. The basic list of customer requirements considered by Caterpillar is as follows:

- Better performance
- Lower owning and operating costs
- Greater comfort / ergonomics
- Increased operator and environmental safety
- Increased reliability
- Aesthetics
- Modular design

Some of the major customer requirements are technically established to analyze product concepts and they are:

- Horse power > 700
- Lower track and engine maintenance
- Bigger bulldozer (at least 3' wider and 1' taller)
- Bigger ripper to penetrate and loosen land during earth-moving (twice as big)

Two basic approaches for redesigning the D9 were considered [25] [26] [28].

- First, Caterpillar could use the basic D9 model and scale it up with bigger parts to meet the performance requirements.
- The second concept consisted of complete re-designing; this would involve greater effort from the Research and Development (R&D) department.

The target price for the new model is incrementally established based on the current model (D9). The D9 in 1977 was priced at \$ 259,035 (including A/C, Ripper and Dozer) [24] and the hypothetical price a customer is willing to pay for every improved physical attribute is listed in Table 3.

Table 3: Target prices for functions (hypothetical – personal estimates)

1. More horsepower	\$ 75,000
2. Improved track performance	\$ 20,000
3. Modular design helping repair and assembly	\$ 15,000
4. For decreasing operating costs	\$ 10,000
5. Increased operator safety	\$ 10,000
6. Improved cabin (ergonomic)	\$ 20,000
7. Aesthetics	\$ 5,000
8. Better bulldozer	\$ 5,000
9. Better ripper	\$ 5,000
10. Other factors	\$ 20,000

The incremental pricing technique is currently not in practice due to the heavy competition. This is particularly true for the computer industry. But in the late 70s, the price of tractors was increasing and the customer was willing to pay the increase in price for a better model.

The price a customer is willing to pay for the new product, the Target Price, is obtained by adding all the prices of improved physical attributes to the price of D9, and it is calculated to be \$ 444,035. The desired profit “*is usually determined by the financial rates of return*” [2]. In the current case study, ROS is used to measure the desired profit to be \$ 88,807 at 20% (over sales price). The target cost is then estimated using the equation

$$\begin{aligned}
 \textit{Target cost} &= \textit{Target Price} - \textit{Desired Profit} \\
 &= \$ 444, 035 - \$ 88,807 \\
 &= \$ 355,228
 \end{aligned}$$

Product concepts must be analyzed to see if they can be manufactured within the target cost. Product re-designing concept 1, that involves scaling up, can meet the target cost (estimated, exact cost not available) as the manufacturing processes are the same. The re-designing concept 1 would not involve any changes in the processes, materials, work-methods and many components can be made common with the D9. The requirement by R&D and the risk of marketability will be less. But it involves some major tradeoffs, such as the increased weight makes it hard to operate, increasing wear and making it cumbersome to assemble or transport. No real estimates for the cost of manufacturing the first concept are available and it was assumed to be \$ 375,000. This cost almost meets our requirement of target cost. But it would have been very difficult to manufacture such a large tractor. For example, a tractor-size link would have been needed for the scaled-up D10 and was considered impractical [23]. In this scenario, Concept 2, involving re-designing becomes our only option. For the purpose of the case study, the initial estimate for manufacturing concept 2 is taken to be \$ 400,000. This makes our concept profitable (to about 10%) and further efforts must be taken to increase the profit margin to 20% as desired. The next step determines design specification based on customer requirements. It also identifies potential candidates for cost reduction.

4.4.3 Product Design and Development

The comprehensive list of product demands is obtained by the help of the Pugh Method [15] and Caterpillar's list of customer demands [24] is shown in Table 4.

Table 4: List of customer attributes

<p>Performance / Capability</p> <ul style="list-style-type: none"> i) Productive ii) Efficient iii) Predictable iv) Versatile v) Severity capability vi) Smooth/Responsive ride <p>Operating costs</p> <ul style="list-style-type: none"> i) Reliable ii) Serviceable iii) Durable iv) Maintainable v) Repair costs vi) Fuel Economy <p>Comfort / Ergonomics</p> <ul style="list-style-type: none"> i) Comfortable ii) Operable iii) Quiet iv) Visibility 	<p>Safety / Environment</p> <ul style="list-style-type: none"> i) Emissions ii) Sound iii) Safety <p>Perceptions / Impressions</p> <ul style="list-style-type: none"> i) Technology leader ii) Appearance iii) Sturdy / Quality <p>Costs</p> <ul style="list-style-type: none"> i) Lower cost <p>Others</p> <ul style="list-style-type: none"> i) Transportable & Reliable ii) Improved dozer & ripper iii) Improved drive
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The customer requirements listed above are correlated to product components/functions so as to determine the candidates for major redesign using QFD. The resultant QFD table is shown in Table 5.

The important customer requirements are listed on the left-hand side of the table and the point to which (on a scale of 5) these requirements are satisfied (hypothetical) in

the current (D9) and new (D10) models is listed on the far right side. The desired level (D10) is divided by the current level (D9) to obtain the ratio of importance (Table 4).

Some functions are more marketable than others are and due weight should be given to user-preferences. This weight is given by multiplying the ratio of importance by a value known as Sales point. The sales point, which is the marketing weight, for each customer requirement is determined hypothetically and multiplied with the ratio of improvement to obtain the absolute weight. Ideally, sales point should be limited within the range of 0.5 to 1.5 to avoid excessive influence of marketing. In the current analysis, a constant sales ratio of 1 is considered, as the marketability of functions is not precisely known. This makes the absolute weight equal to the ratio of improvement. The demanded weight for every requirement is calculated as a percentage of the total absolute weight. These values are determined hypothetically in the analysis.

The complete list of components or assemblies is taken on top of the table and the extent to which every component effect the performance of a customer requirement (correlating value) is mentioned in the body of the table. These correlating values are also hypothetical and are multiplied with the demanded weight of every requirement and added along the column.

The customer requirements are correlated to components. For example, Undercarriage helps improve the performance of drive and is strongly correlated (9). The decreased wear will result in lower costs and it is less strongly correlated to Undercarriage (3) similar to perceptions. Final cost is strongly influenced (9) due to the costs incurred in designing undercarriage, and comfort is improved due to the improved drive (1). Similarly, correlation between customer requirements and all physical components considered for re-designing is established.

The ratio of importance is determined by dividing the level of satisfaction to be obtained for the new model by the current level. For example, the performance is currently at a level of 2 on a scale of 5 and the new model will achieve a level of 5. This will give a ratio of importance of 2.5 for performance capability. Similarly, the ratio of importance is calculated for the other functions. The ratio of importance is multiplied by the sales point to get absolute weight. The demanded weight is calculated as the percentage of the total of absolute weight.

The values of correlation are multiplied by the demanded weight and added up along the column. The relative importance of every component is obtained by calculating the percentage of the totals. For example, the sum of 9 times 22.9, 3 times 12.2, 1 times 18.3, 3 times 9.2 and 9 times 6.9 obtains the total value for undercarriage. The current analysis lists the important components based on the correlating values, which are determined hypothetically.

QFD Table for Tractor

Table 5: QFD table to identify candidates for the re-design of a tractor

QFD Table for Tractor																				
Product Attributes / Components	Importance (weight)	Under Carriage	Engine	Cabin	Drive train (belt)	Bulldozer	Ripper	Transportation (modularity)	Repair (ease and costs)	Materials	Frame Size and Weight	Transmission	Overall Safety	Optional equipment	D9 Model (on a scale of 5)	D10 Model (on a scale of 5)	Ratio of Importance(Improvement)	Sales Point	Absolute Weight	Demanded weight
Customer requirements																				
Performance / Capability		9	9	3	3	3	3			1		3		1	2	5	2.5	1	2.5	22.9
Owning and Operating Costs		3	3	9	1	1	1	3	9	1				1	3	4	1.333	1	1.33	12.2
Comfort / Ergonomics		1	1	9			1	1				1	9	3	2	4	2	1	2	18.3
Safety / Environment				3					9						3	4	1.333	1	1.33	12.2
Perceptions / Impressions		3	3	3	3	3	3	3	3		3	3		3	3	3	1	1	1	9.2
Costs		9	9	9		3	3		1	3			3	3	4	3	0.75	1	0.75	6.9
Others									1	1			1	3	2	4	2	1	2	18.3
Total	2523	350	350	469	108	147	147	64.1	272.5	74	27.5	115	204	193					10.9	100.0
Percentage (%)		14%	14%	19%	4%	6%	6%	3%	11%	3%	1%	5%	8%	8%						
Company now																				
Competitor 1/ (D9)																				
Plan (D10)																				

9- Strongly related, 3- Less strongly related and 1- Weakly related

Based on the hypothetical values, the major components that need to be considered for re-designing are under-carriage, engine, cabin and reparability of equipment. The actual process of re-designing is technical and is considered out of scope for the current report. But, it is supposed that the re-designing is done to meet the customer requirements and the report proceeds to identify potential cost reduction candidates.

After the re-designing, the costs of manufacturing components are related to the importance of components so as to identify potential cost reduction candidates. This is achieved by using value engineering and the detailed calculations of value engineering are shown in the appendix.

The weight of each function is determined based on the total functionality and the values are determined hypothetically. The sum of the weights should equal the number of involved functions (7 in the current case). The contribution of each component to the satisfaction of a function is determined. The sum total contribution of all components for every function should equal a value of 100. The percent importance of a component is determined by the sum total of the product of the contribution of the components with the importance of every function. The percent of total cost consumed by a component is divided by the percent of importance to obtain the value index for that component. All the values in this analysis are hypothetical. The Table 6 illustrating the calculation of value indices for different products is shown below.

Table 6: Value Indices of components (hypothetical)

Components	% of total cost consumed	% importance of components	Value index
Under Carriage	12.5	12.11	1.03
Engine	7.5	22.71	0.33
Cabin	15	15.61	0.96
Drive train (belt)	10	6.07	1.65
Bulldozer	7.5	4.82	1.56
Ripper	7.5	4.82	1.56
Transportation (modularity)	10	4.89	2.04
Repair (ease and costs)	10	6.11	1.64
Materials	2.5	2.41	1.04
Frame Size and Weight	5	3.98	1.26
Transmission	5	4.64	1.08
Overall Safety	5	5.75	0.87
Optional equipment	2.5	6.07	0.41
Total	100	100.0	

Potential cost reduction candidates are the components with value indices greater than 1 and they are drive train, bulldozer, ripper, modularity, repair, and frame size and weight. Supposing that the cost of manufacturing the mentioned components is reduced to obtain a value index of 1, the present cost of manufacturing is calculated as shown in Table 7(based on hypothetical value engineering tables):

Table 7: Cost reductions obtained by component

Component	Current Cost	New Cost
Drive train	\$ 40,000	\$ 24,280
Bulldozer	\$ 30,000	\$ 19,280
Ripper	\$ 30,000	\$ 19,280
Modularity	\$ 40,000	\$ 19,560
Repair	\$ 40,000	\$ 24,440
Frame Size & Weight	\$ 20,000	\$ 15,920

The reduced cost of manufacturing is then calculated to be \$ 322,760. The profit margin at this cost is about 27%.

4.4.4 Recommendations for Cost reduction

Some recommendations for reducing the cost of manufacturing the above mentioned components are as follows.

1. Different materials can be investigated to reduce the cost of manufacturing.
2. The customer demands and needs of a operator's station must be listed from the QFD or value engineering table along with their importance. This process will help us in concentrating our efforts on the correct issues.
3. Transportability can be studied along with the marketing department. The amount of transportability required for an international market will be greater than a national market and our efforts must be in proportion to the area of the market covered.
4. The components that are most fatigued must be made modular and more serviceable to provide for easy replacement.

5. The transportability can be studied from a servicing perspective and the method by which spare parts and tools are distributed should be analyzed. The spare parts must be available separately, but must be easy to assemble.
6. The value engineering table must be made dynamic to verify the cross links between the several components and functions instead of a one time thing.
7. The service department can be contacted and most wearing parts can be identified to improve performance.
8. Implement concurrent engineering to avoid the designing of similar part by various departments.

4.4.5 Production and Logistics

This step of target costing is the actual implementation phase. The approved product concept is taken and the designs are set in production. Data is collected to verify the costs and performance of products. Opportunities for further improvement are identified during implementation.

If the costs of production vary from the estimates, the value-engineering phase must be conducted again in order to reduce the total manufacturing costs. As the new product becomes old, competition catches up and the company needs to add more features and reduce the prices for old features. This constant process of updating a product should be carried on in order to stay ahead of competitors.

4.5 Results

Retroactively analyzing the customer requirements and the feasibility of the product concepts, it is more beneficial to re-design the D9 than to make a scaled up version. The target costing analysis achieved the following:

1. Compared different concepts based on manufacturing feasibility along with their profit making ability.
2. Applied QFD and identified components to be re-designed based on customer requirements. It is known that these were the components that were re-designed to achieve the desired profit in real life. Conducting a target costing analysis

would have helped the Caterpillar designing team in identifying the components to be re-designed.

3. Identified potential cost reduction candidates to obtain the desired profit. If the cost of manufacturing in reality was higher than the selling price, value engineering would have helped Caterpillar in cost reduction. However, no data is available to compare the real cost of manufacturing to the estimates.

5 Sensitivity Analysis

5.1 Objective

The target costing analysis performed in the previous sections considered several factors and the factors considered can be classified as objective and subjective factors. The objective factors have been quantified while the subjective factors were mentioned and briefly analyzed. All the factors along with their respective category are shown in Table 8. The objective factors are considered are the sensitivity of profit to these factors is determined.

Table 8: List of Factors

#	Factor	Category
1	Target Price	Objective
2	Target Cost	Objective
3	Actual cost of manufacturing	Objective
4	Methods and Processes of Manufacturing	Subjective
5	Duration of target costing	Subjective
6	Complexity of Products	Subjective
7	Profit	Objective

The target costing analysis considered the above factors, but it did not consider the effect of variation among these factors. So it becomes essential to introduce variations into the objective factors and study the effect of variations on the end result. The purpose of this analysis can be summarized as follows:

1. Identify the relative importance of factors that affect our profit making ability.
This will help us to concentrate our efforts into obtaining more accurate information for more sensitive factors.

2. Analyzes the sensitivity of overall profit-making ability. This is done by building an Excel worksheet and by varying the important factors that effect our decision making process.

5.2 Analysis

The sensitivity analysis is conducted using the following methods:

- One-at-a-time procedure to determine decision reversal points.
- The Monte-Carlo simulation for risk analysis based on randomly generated nominal variables.
- Variation of all factors including profit percentage on an excel spreadsheet.

5.2.1 One-at-a-time procedure

This procedure involves varying one factor at a time and to calculate the break-even point (No loss – No profit). This process helps us in identifying the most important factors, also stated the factors that influence the profit to a great extent with small changes in their value.

Most likely estimates for all factors are considered and one factor is varied after another and all the remaining factors are kept constant to determine the extent at which profit is no longer made. For further details refer to [22]. Table 9 shows the sensitivity of various factors.

Table 9: One-at-a-time approach

Factor	Most likely Estimate	Estimate Outcome	Change Amount	Change amount as % of most likely
Target Price	\$ 444,035.00	\$ 400,000.00	\$ 44,035.00	9.92%
Actual Cost of Manufacturing	\$ 400,000.00	\$ 444,035.00	\$ (44,035.00)	-11.01%
Target Cost	\$ 355,228.00	Target cost is derived based on profit requirements		
Profit	\$ 88,807.00	Profit is equated to zero and hence cannot be considered		

It can be seen from Table 9 that Actual cost of manufacturing is more important than the target price.

5.2.2 Monte-Carlo Simulation

Monte-Carlo simulation is used for analyzing the risk involved. Various quantitative factors are identified and the variation of the values is expressed in terms of distributions. The most commonly used variations are normal distribution and uniform distribution.

In the current project it is assumed that all qualitative factors are normally distributed around their mean values. Normal distributions are generated by using mean values, standard deviations and random normal deviates. According to Ref 22. "A random normal deviate is merely a random number of standard deviations from the mean. The standard normal deviates are generated using Microsoft excel functions. Corresponding to the values of target price and actual cost of manufacturing, the profit generated is measured.

According to Monte-Carlo, the number of trials to be performed to analyze the risk is obtained by stabilizing the answers. Since the trials are manually generated the total number of trials is limited to 20. The assumptions about the mean and standard deviations are mentioned in table 10.

Table 10: Monte-Carlo Analysis

Calculation						
Profit = Target Price - Actual Cost of Manufacturing						
#	Target Price		Actual Cost of Manufacturing		Profit	Profit (in %)
	Mean, Std Dev	Value	Mean, Std Dev	Value		
1	\$444035, \$50,000	429023.392	\$400000, \$25000	410559.40	18464.0	4%
2	"	380150.8416	"	395561.89	-15411.1	-4%
3	"	456247.8654	"	402231.93	54015.9	12%
4	"	507858.677	"	397779.58	110079.1	22%
5	"	503952.511	"	361226.31	142726.2	28%
6	"	530691.6552	"	383164.74	147526.9	28%
7	"	334855.618	"	428040.06	-93184.4	-28%
8	"	432325.9378	"	405468.00	26857.9	6%
9	"	498786.1263	"	420951.80	77834.3	16%
10	"	389699.9675	"	387589.09	2110.9	1%
11	"	409524.792	"	368247.32	41277.5	10%
12	"	359513.3836	"	439792.33	-80278.9	-22%
13	"	351689.4555	"	411849.38	-60159.9	-17%
14	"	395153.5251	"	394314.38	839.1	0%
15	"	405359.6473	"	412677.67	-7318.0	-2%
16	"	338138.4391	"	361734.03	-23595.6	-7%
17	"	415638.7564	"	436202.66	-20563.9	-5%
18	"	423832.6216	"	352477.31	71355.3	17%
19	"	450777.6527	"	389377.81	61399.8	14%
20	"	425760.3524	"	485681.68	-59921.3	-14%

Based on the above analysis, chances for making a profit more than 20% is 15% and the chances of making a profit of more than 10% is about 40%. The chances of making a profit are about 55%. The above results only become accurate when the trials are repeated till the final results get stabilized. (Profit is calculated based on return on sales)

5.2.3 Excel spreadsheet analysis

The factors that effect the end result are subject to uncertainty. The exact distributions for the factors are not known, so the values were changed manually to study the effects on the end result of product profitability. The process is mainly driven by the factors listed below:

1. Target Price
2. Profit

3. Actual Cost of Manufacture

The target price is varied from 15% less than \$ 444,035 to 15% more (7 different cases) with an interval of 5%. The values considered are shown in Table 11.

Table 11: Target Prices

Target Price 1	\$ 377,429
Target Price 2	\$ 399,631
Target Price 3	\$ 421,833
Target Price 4	\$ 444, 065
Target Price 5	\$ 466,238
Target Price 6	\$ 488,238
Target Price 7	\$ 510,640

For each one of the cases, the profit margin is varied from 0% to 30% with an interval of 5% (7 cases) and the number of profitable cases for each target price are identified. The total number of different cases thus considered for every value of actual cost of manufacturing is 49 (7 target prices times 7 profits). The Excel worksheet with formulas and sample calculations when the actual cost of manufacturing is \$ 300,000 is shown in the appendix. The summary of results is shown in Table 12.

Table 12: Summary of Sensitivity Analysis

Actual Cost of Manufacturing	# of cases that are profitable or break-even	# of Non-Profitable cases
\$ 300,000	44	5
\$ 310,000	43	6
\$ 320,000	40	9
\$ 330,000	38	11
\$ 340,000	34	15
\$ 350,000	32	17
\$ 360,000	27	22
\$ 370,000	26	23

\$ 380,000	21	28
\$ 390,000	20	29
\$ 400,000	16	33

5.3 Sensitivity Analysis Results

One-at-a-time approach shows that the final results are more sensitive to changes in actual cost of manufacturing. Monte-Carlo simulation shows that the chances of making a profit are reasonable (55%). The important aspect to be considered is that the standard deviation associated with target price is twice the standard deviation associated with the actual cost of manufacturing. The results from Monte-Carlo vary depending on the standard deviation and the number of trial runs.

It can be noticed from the above table that the number of chances of making a profit exceed the number of chances of making a loss until the cost of manufacturing is less than \$ 380,000. Hence, depending on the initial estimate of cost of manufacturing and the accuracy of the estimate, a decision to manufacture or not can be taken.

At the reduced cost of manufacturing \$ 322,760, the chances of making a profit are 39 out of 49 (with varying target prices and profits).

6 Conclusions

This report explained the process of target costing and mentioned the aspects to be considered during the implementation of target costing in a manufacturing firm. It also illustrated the process of applying target costing with a real life analysis. It is hoped that the illustration of the process along with the analysis will help industries in implementing target costing.

Some aspects not covered by the current report include the measurement of product life cycle costs and the establishment of organizational and employee preparedness. The importance of product life cycle costs depends on the type of the product. The costs of ownership were considered. But, the costs of disposal and environmental effects were not considered. Methods to analyze organizational and employee preparedness were

mentioned. But, precise methods for evaluating software, employee understanding of target costing, etc. are not mentioned. The case study does not address the change of customer attributes over the life cycle of the product. Last but not least, the actual process of designing is not described, due to the involved complexity.

The process of target costing and the case study illustrate the following points:

- The feasibility and the method of integrating product designing and manufacturing into the overall planning.
- Application of QFD to provide the designing team with goals.
- Designing takes the concerns of manufacturing from the initial stages of concept development..
- Identifies the components / functions to be designed or innovated.
- Identifies the components / functions to reduce the costs.
- Increases the understanding between functional departments.

It is finally concluded that target costing will provide a company with the means to improve decision making by structuring the process of product introduction and designing.

7 References

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8 Appendix

8.1 Table showing the importance of functions for Value Engineering Analysis.

The components and functions are mentioned before.

Functions \ Components	% importance of components	Performance / Capability	Operating Costs	Comfort / Ergonomics	Safety / Environment	Perceptions / Impressions	Costs	Others	Total
weight of each function	-	2.45	1.50	1.00	0.50	0.30	1.00	0.25	7.00
% importance of functions	-	35.0%	21.4%	14.3%	7.1%	4.3%	14.3%	3.6%	100%
Under Carriage									
Engine									
Cabin									
Drive train (belt)									
Bulldozer									
Ripper									
Transportation (modularity)									
Repair (ease and costs)									
Materials									
Frame Size and Weight									
Transmission									
Overall Safety									
Optional equipment									
Total									

8.2 Table illustrating the extent to which each component helps satisfy the demand

Functions Components	% importance of components	Performance / Capability	Operating Costs	Comfort / Ergonomics	Safety / Environment	Perceptions / Impressions	Costs	Others	Total
% importance of functions	-	35.0%	21.4%	14.3%	7.1%	4.3%	14.3%	3.6%	100.0%
Under Carriage		20	5	5	5	15	15	5	70
Engine		30	30	10	10	10	20	10	120
Cabin		10	10	40	20	20	10	15	125
Drive train (belt)		5	5	5	10	5	10	5	45
Bulldozer		5	5	5	5	5	5		30
Ripper		5	5	5	5	5	5		30
Transportation (modularity)			10	5	5	10	7.5	5	42.5
Repair (ease and costs)		5	10		5	10	7.5	10	47.5
Materials		5				5	2.5	2.5	15
Frame Size and Weight		5	5	5			2.5	2.5	20
Transmission		5	5	5		5	5	5	30
Overall Safety			5	10	30	5	5	5	60
Optional equipment		5	5	5	5	5	5	35	65
Total		100	100	100	100	100	100	100	

8.3 Table illustrating the calculation of the importance of functions.

Functions		% importance of components	Performance / Capability	Operating Costs	Comfort / Ergonomics	Safety / Environment	Perceptions / Impressions	Costs	Others	Total
Components										
% importance of functions		-	35.0%	21.4%	14.3%	7.1%	4.3%	14.3%	3.6%	100.0%
Under Carriage			7.00	1.07	0.71	0.36	0.64	2.14	0.18	12.11
Engine			10.50	6.43	1.43	0.71	0.43	2.86	0.36	22.71
Cabin			3.50	2.14	5.71	1.43	0.86	1.43	0.54	15.61
Drive train (belt)			1.75	1.07	0.71	0.71	0.21	1.43	0.18	6.071
Bulldozer			1.75	1.07	0.71	0.36	0.21	0.71	0.00	4.821
Ripper			1.75	1.07	0.71	0.36	0.21	0.71	0.00	4.821
Transportation (modularity)			0.00	2.14	0.71	0.36	0.43	1.07	0.18	4.893
Repair (ease and costs)			1.75	2.14	0.00	0.36	0.43	1.07	0.36	6.107
Materials			1.75	0.00	0.00	0.00	0.21	0.36	0.09	2.411
Frame Size and Weight			1.75	1.07	0.71	0.00	0.00	0.36	0.09	3.982
Transmission			1.75	1.07	0.71	0.00	0.21	0.71	0.18	4.643
Overall Safety			0.00	1.07	1.43	2.14	0.21	0.71	0.18	5.75
Optional equipment			1.75	1.07	0.71	0.36	0.21	0.71	1.25	6.071
Total			35.00	21.43	14.29	7.14	4.29	14.29	3.57	100

8.4 Summary of Calculations of Sensitivity Analysis

(With \$ 300,000 actual cost of manufacturing)

Basic Information			
Current Price of the D9 Model (\$\$)	=	289,035	
Base Estimate for the price of D10 model	=	444,035	
Case	% change	Target Price	
1	-15%	377430	
2	-10%	399632	
3	-5%	421833	
4	0%	444035	
5	5%	466237	
6	10%	488439	
7	15%	510640	
Every case is analyzed for different returns (ROS)			
Total Cost of Manufacturing the D10 Tractor (\$\$)	=	300,000	
Summary of Results			
Total # of cases when TC>TCM	=	5	Not profitable 10%
Total # of cases when TC<TCM	=	44	Profitable 90%
Total # of cases	=	49	

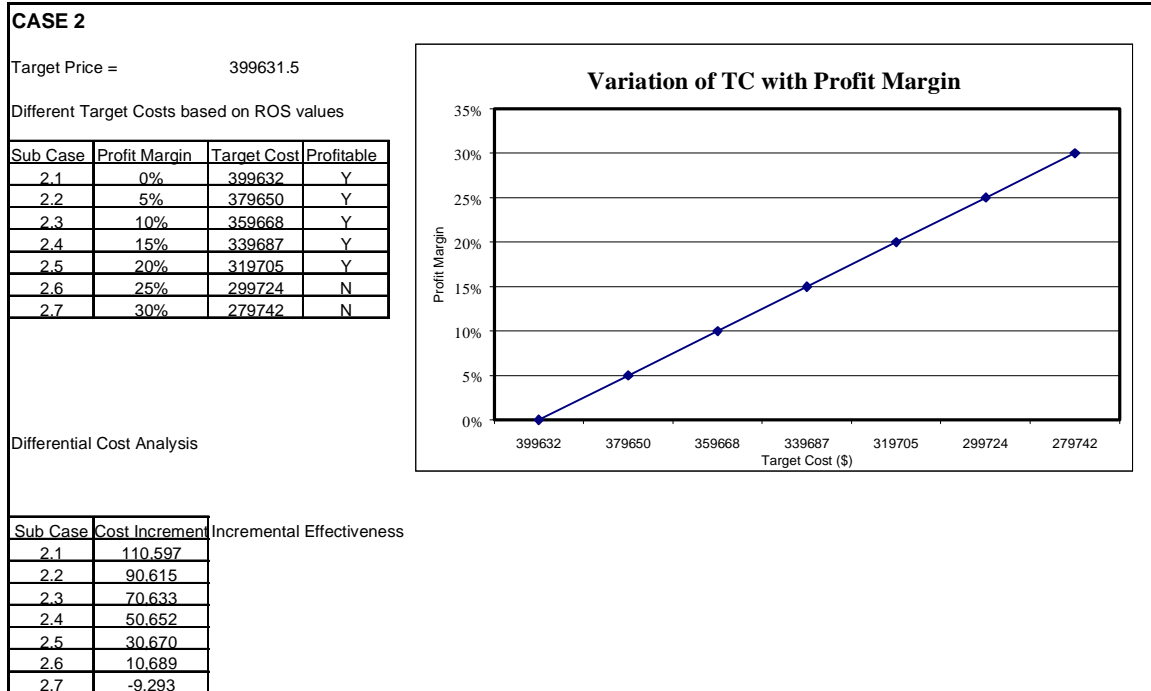
8.5 Sensitivity Analysis for the Target Price of \$ 377429.75

CASE 1			
Target Price =	377429.75		
Different Target Costs based on ROS values			
Sub_Case	Profit Margin	Target Cost	Profitable
1.1	0%	377429.75	Y
1.2	5%	358558.26	Y
1.3	10%	339686.78	Y
1.4	15%	320815.29	Y
1.5	20%	301943.8	Y
1.6	25%	283072.31	N
1.7	30%	264200.83	N
Differential Cost Analysis			
Sub_Case	Cost Increment	Incremental Effectiveness	
1.1	88.395		
1.2	69.523		
1.3	50.652		
1.4	31.780		
1.5	12.909		
1.6	-5.963		
1.7	-24.834		

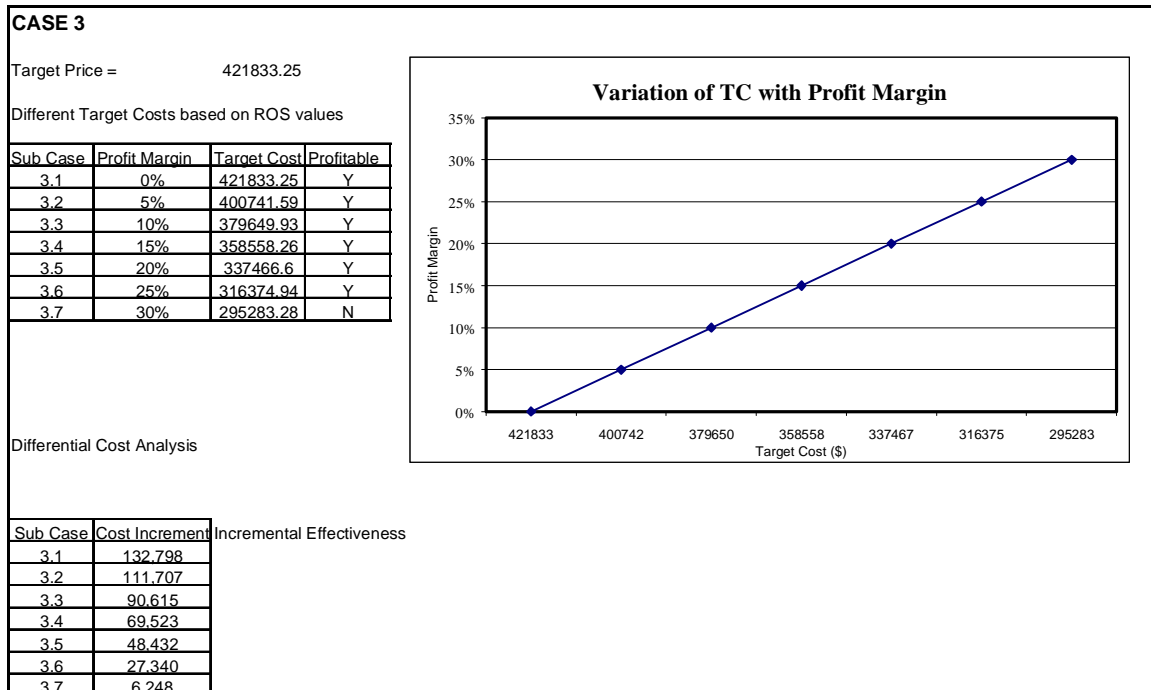
Variation of TC with Profit Margin

Profit Margin (%)	Target Cost (\$)
0%	377430
5%	358558
10%	339687
15%	320815
20%	301944
25%	283072
30%	264201

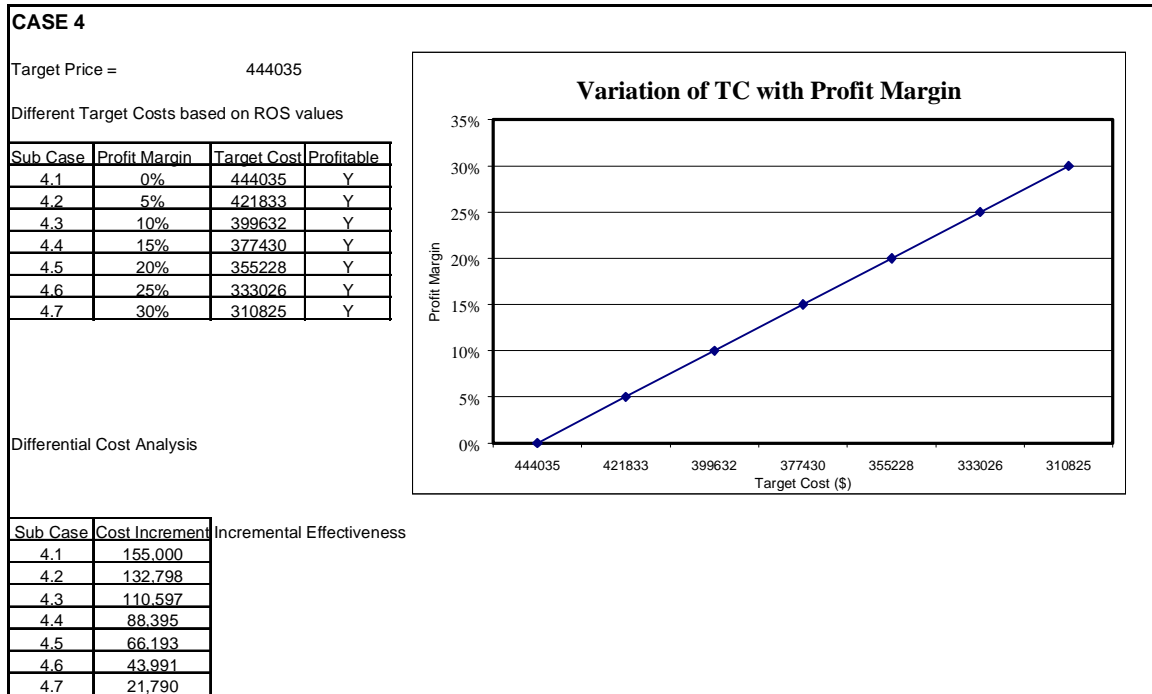
8.6 Sensitivity Analysis for the Target Price of \$ 399631.5



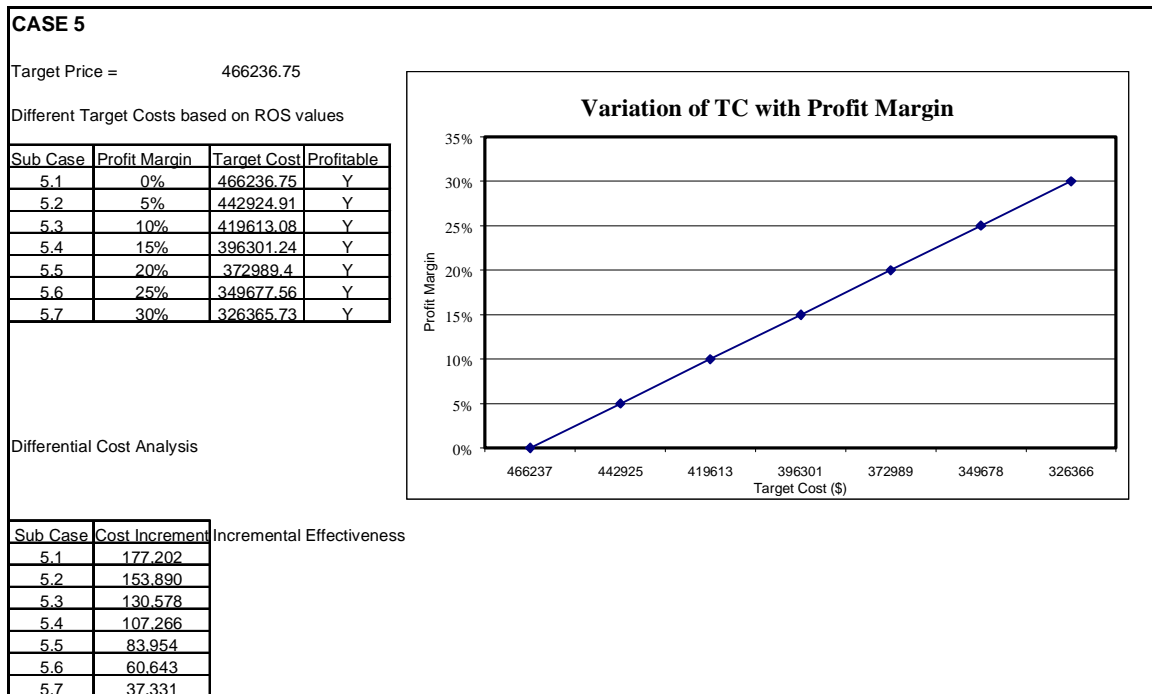
8.7 Sensitivity Analysis for the Target Price of \$ 421833.25



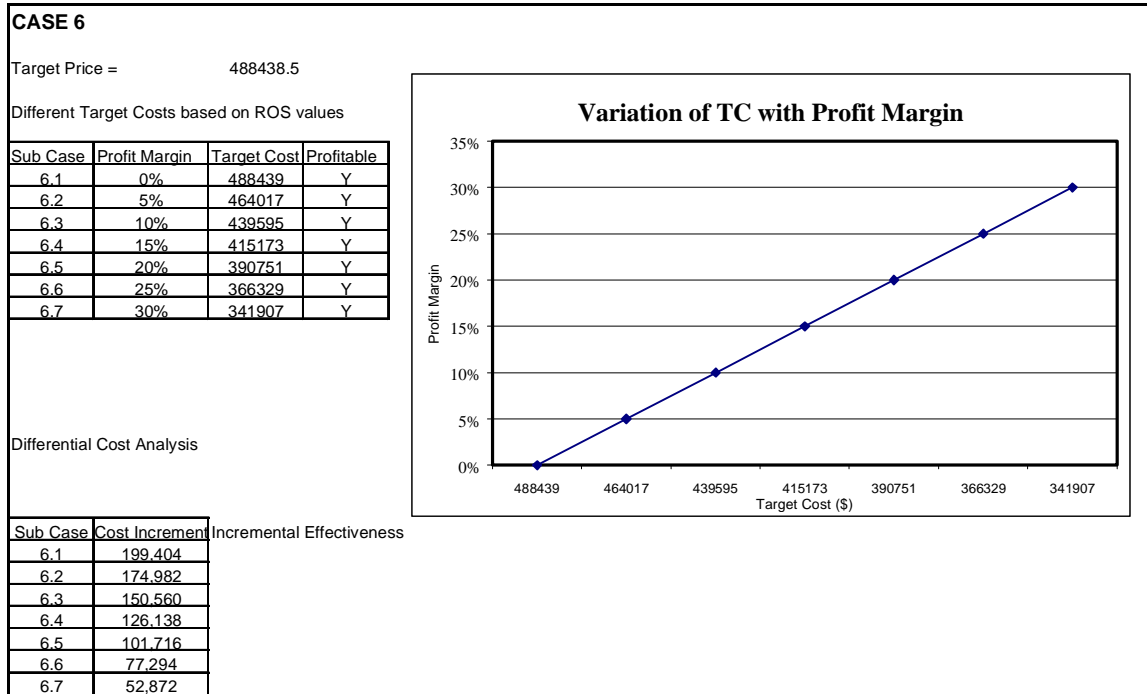
8.8 Sensitivity Analysis for the Target Price of \$ 444065



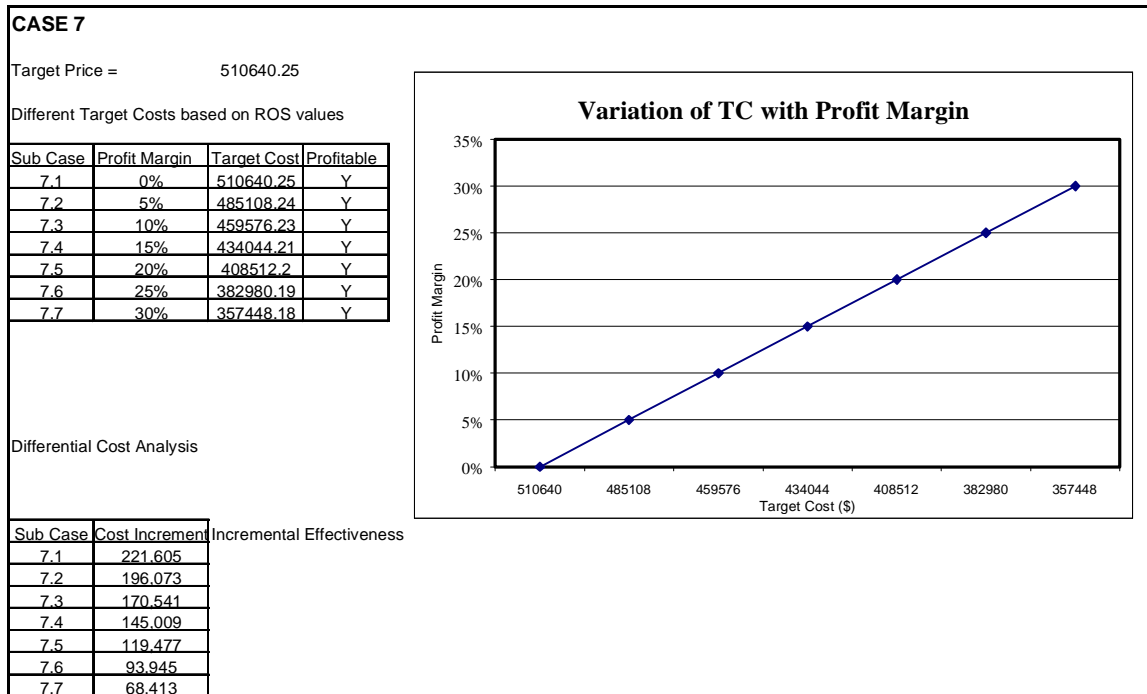
8.9 Sensitivity Analysis for the Target Price of \$ 466238.76



8.10 Sensitivity Analysis for the Target Price of \$ 488438.5



8.11 Sensitivity Analysis for the Target Price of \$ 510640.25



VITA

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