Cost-Efficient Design

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With 320 Figures

Springer

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Editor's Preface

This translation has been developed from the fifth edition (2005) of the Authors' German text, "Kostengünstig Entwickeln und Konstruieren". The discussion on the methods of cost reduction and cost-driven design draw heavily on the "Systematic Method of Design", the development of which is described in German language literature of the past several decades. An English language edition [Pah05][1] of a classic text is available. In this approach, the design process is divided into the phases of task clarification, concept development, preliminary design (embodiment) and the detailed layout. Design forms the core of the coordinated process of modern product development, known under the rubric of Concurrent Engineering. This book stresses the collaboration of the different departments in a company, which is essential for the development of reliable and low-cost products.

The first edition was a best seller for a number of years. Eventually, as the fields developed, a second edition came out in 1998. The development of methods (a major portion of that from the research in the authors' Institute,) as well as the demand for the book, led to the third, fourth and fifth editions appearing in quick succession. It was the first book that, with a scientific approach, showed the connection between design, production processes and the product costs. This provided the basis for cost-driven product design.

The overriding goal in preparing this translation was to convey the ideas of the authors as closely as possible.

German references

The references in the book are primarily to German literature. No attempt has been made to provide references to English language literature on the subject, as those are abundantly available to the English language readers from other sources.

There are references to DIN (Deutsche Industrie Normen – German industry standards) and VDI (Verein Deutscher Ingenieure – German Society of Engineers) guidelines. Knowledge of either is not necessary in following the book. They have been retained from the German edition as the original source material. Many of these are available in English or have been adopted as ISO standards.

Notation

The book is intended for an international audience. Although the currency used is the US$, the $ sign is placed after the number. As a compromise, numbers are shown as follows: 12 345.67 instead of 12,345.67 as is customary in the USA, or

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[1] Expressions in square brackets denote References at the end of the book.

12.345,67 as used in Europe. The citations of **Figure** numbers are in **bold** where the pertinent figure is discussed in detail. Likewise, in the Index the page numbers are in **bold** where the corresponding keyword is discussed at length. Important sentences have also been printed in **bold**. In the appendix we satisfied a wish from the readers to have a consolidation of the most important checklists and rules for practical cost reduction work. We hope this will be helpful. These guidelines for cost reduction have a grey narrow band at the end of a page.

On a personal note, I met Prof. Ehrlenspiel for the first time in 1986. The year before, in 1985, he had published the first edition of the present book. During the year 1987–88, I spent my sabbatical year at the Institute of Mechanical Design (now, Product Development) at the Munich University of Technology. Since that time, I have been fortunate to be in continuous contact with him and his colleagues at the Institute. My 1997 book [Hun97] is an outcome of this association.

South Hero, Vermont and Fabbrica, Toscana 2006 *Mahendra Hundal*

Preface to the First English edition

The authors are pleased that after several years of fruitful co-operation with Professor Mahendra Hundal, the English translation of the 5th Edition of the German book is finally here.

We thank him for the empathy and intuitive understanding, as well as his tenacity, in carrying out the translation and editing the final product. Special thanks are also due to Dr-Ing. M. Mörtl, who, as a successor to Dr.-Ing. A. Kiewert, worked on corrections to the manuscript.

We are pleased too, as always, for good cooperation with Springer-Verlag, which realized the translation project in co-operation with ASME. In this regard, we make a particular mention of Dr. D. Merkle.

Munich, September 2006 *Klaus Ehrlenspiel • Alfons Kiewert • Udo Lindemann*

Preface to 5th Edition

Reducing costs is a continuing task, and the reason for this fifth edition of the book.

Contents and breadth of the book were developed at the Munich University of Technology, and were the basis for the course “Cost Management in the Machine Industry” and for a VDI seminar entitled “Technical Designers Lower Costs”. It is also used for courses at other universities and technical colleges.

The primary changes from the fourth edition are additions to the literature and correction of errors that were discovered.

Lowering costs is important in all countries. Therefore, the translation of the book into English has been an ongoing task, being carried out by Professor Hundal of the University of Vermont, USA. It is soon to be published by Springer Verlag, New York, in co-operation with the ASME.

Munich, April 2005 *Klaus Ehrlenspiel • Alfons Kiewert • Udo Lindemann*

Preface to the 4th German edition

The pressure of costs is continually increasingly. Target-cost based design and development are of current interest and more necessary than ever before. The cost reduction of –30% described in Figure 2.3-2 often taken as a "standard precondition", next to an increase in performance in the case of new designs and product revisions!

From the feedback on this book, from industry training courses and industry contacts we know that the book helps in the process. So, every few years a new edition comes out. We are happy, of course!

This time much of the contents were re-worked and new material added.

We have always known from the practice how important the pursuit of costs is during a project. Therefore we have introduced two more systems for this purpose in Sect. 4.8.3.2.

The prolongation of the service life of products benefits both the user and the manufacturer. Therefore Chap. 5 on "Influencing the lifecycle costs", was enhanced by Sect. 5.4.

Then there is the always-current topic of variant management! The demand for customer-specific products works diametrically opposite to the wish for low costs. Variant management must help in finding a compromise. The contents of Sect. 7.12 were revised and expanded. Two new examples for modular design were added: Modular design application in Porsche sports cars and for tractors (Prof. Dr.-Ing. Renius).

The costs and prices were converted to the Euro. And this, despite the fact that all numerical data in the book are only "relative values". On one hand the numbers must not show the original industry values in the examples, on the other hand it is not possible to keep the cost information continuously up-to-date. The matter is only of the examples from practice, which anyway always contain company-specific cost information (see Figure 7.13-2).

Further, a table of contents in English was inserted as a first step toward a complete English translation of the book. We thank Prof. Hundal of the University of Vermont for that. This helps foreign readers get an orientation to the subject and introduces important specialist terms to German readers.

Finally, this took care of the new spelling, adding to the literature citations and the correction of mistakes.

During this extensive revision, Dr.-Ing. A. Kiewert has carried the main burden. Mr. H. Nyncke M.A. has carried out the computerization of the manuscript

over several months. To them, many thanks for their commitment. Springer Verlag has supported us in well-proved manner.

Our wish for you as readers is, that you get a better "cost view" with the book and tackle the "cost lowering" problems.

Munich, May 2002 *Klaus Ehrlenspiel • Alfons Kiewert • Udo Lindemann*

Preface to the 3rd German edition

The book apparently meets a strong need in practice and teaching. Therefore the 3rd edition is here after a good year.

With regard to the contents, the sections on evaluation and variant management were greatly enhanced. In particular we satisfied a wish from the readers concerning a consolidation of the most important checklists and rules for practical cost reduction work. Also, it is hoped that the clearly discernible appendix on the "guidelines for cost reduction" will be helpful for that.

Of course the literature was added to, and the mistakes found were corrected. In cost reduction there is a consistent improvement potential.

We, together with the publisher, appeal to you to implement this also!

Munich, June 1999 *Klaus Ehrlenspiel • Alfons Kiewert • Udo Lindemann*

Preface to the 2nd German edition

We are publishing this book because we have found that with the thinking and methods described here, 20–30% of the manufacturing costs of the products can often be lowered in the practice – quite apart from the overhead costs and lifecycle costs.

That appears to us to be an intelligent and additional possibility for the stabilization of the much talked about "position Germany". At least, in addition to the simple reduction in personnel, as the sign of "Lean Production".

The book was re-worked completely, vis-a-vis the **1st Edition of 1985**. This is true in particular for Chap. 2 through 6. The experiences from many industry projects and from approximately 90 industry training courses taught in and with the industry were utilized for this. (Sect. 7.13 presents, for example, the results of an almost 20-year cooperation with 8 to 15 companies of the Gear Drives Research Association FVA, under the heading "Cost Benchmarking").

Further, the increasing knowledge in methodical design and development was taken into account: Adapting universal methods to the specific concrete problem, integrated product design with increasing specialization, and emphasis on early development phases, since the essential decisions are made here.

Our aim was to consider the modern production and assembly processes. Generally, there is hardly any relevant literature about their time and cost properties. In addition a lot of things were elaborated upon, and then again dropped for space reasons – sacrificed to the editor's red pencil. Our experience showed that the production technology and parts suppliers' markets are developing so rapidly that for each concrete case the appropriate applicable knowledge must be procured individually. The book can provide only the basic stimuli.

Our **thanks** go, first of all, to all the colleagues and employees of the Institute of Mechanical Design for the contents-related work, in particular Dipl.-Ing. M. Moertl, Dipl.-Ing. J. Wulf, and Dipl.-Ing. U. Phleps.

The scientific support personnel, Dipl.-Ing. C. Geng, Mr Dipl.-Geogr. M. Krämer, Dipl.-Ing. Dipl.-Wirtsch.-Ing. M. Reichart, Ms E. Carbajo and Ms. C. Stubenrauch spent a long time transferring text and figures to the computer.

We also want to thank our sponsors. Many projects that were supported by the DFG, the FVA and the BMFT, have added to the knowledge gained.

Of course, in the same way we have also learned a lot from industry, from the companies and their employees.

The Springer Verlag is to be thanked for the careful realization of the book and good cooperation. In this regard we want to especially mention Dr. Merkle.

Munich, May 1998 *Klaus Ehrlenspiel • Alfons Kiewert • Udo Lindemann*

We would be pleased with your suggestions and critical review.

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Contents

Nomenclature

Page numbers where definitions are given or the symbol's primary appearance, are in parentheses. In the book, **capital letters** (***MC*, *MtC*, *PCs*, *PCe***) are used for absolute quantities and **lower-case letters** (***mc*, *mtc*, *pcs*, *pce***) for quantities as percentages (usually with reference to *MC*).

Symbol	Description
φ	Size ratio (re: size range) (s. Chap. 7.12.5.3)
φ_L	Linear size ratio (Fig. 7.12-23)
Subscript 0	Basic (initial) embodiment (s. Chap. 7.12.5.3a)
Subscript 1	Succeeding embodiment (s. Chap. 7.12.5.3a)
AOC	Administrative overhead costs (Fig. 8.4-2)
AOCAS	Administration overhead costs surcharge rate (Fig. 8.3-3)
AsC	Assembly costs (s. Chap. 7.13.7b)
ASC	Administration and sales costs (s. Chap. 8.4.3b)
ASOC	Administration and sales overhead costs (Fig. 8.4-2)
ASOCS	Administration and Sales overhead costs surcharge rate (Fig. 8.4-4)
CAS	Cost accounting sheet (Fig. 8.3-3)
C_{fix}	Fixed costs (Fig. 8.5-2)
C_{one}	One-time costs (s. Chap. 7.5.1)
C_t	Total Costs (Fig. 8.5-2)
C_V	Specific material cost (s. Chap. 7.9.2.3)
C_V^*	Relative material cost (on volume basis) (s. Chap. 7.9.2.3)
C_{var}	Variable costs (Fig. 8.5-2)
DC	Direct costs (Fig. 8.3-3)
DDC	Design and development costs (Fig. 8.4-2)
DDOC	Design and development overhead costs (s. Chap. 8.4.3)
DDOCS	Design and development overhead costs surcharge rate (Fig. 8.4-4)
DfC	Differential cost with SHC, to a basic variant without SHC (Fig. 9.3-3)
Fix	fix (Fig. 8.5-2)
IC	Product introduction (launch) cost (Malus) (s. Chap. 7.5.1)
IC_p	Introduction cost per product = IC/N_{tot} (s. Chap. 7.5.1)
L_n	Number of lots (s. Chap. 7.5)
LCC	Life-cycle costs (Fig. 5.1-3)
m	Modulus (gear) (Fig. 7.13-4)
MC	Manufacturing cost (Fig. 8.4-2)
MC_w	Manufacturing cost per unit weight (Weight-cost ratio) [$/kg] (s. Chap. 9.3.2.1)
mcs	Ratio of production cost from set-up times (to manufacturing cost) *mcs* = *PCs/MC* (s. Chap. 7.7.1)
mtc	Ratio of material cost (to manufacturing cost) *mtc* = *MtC/MC* (s. Chap. 7.7.1)

MtC	Material cost (inclusive of mass-dependent costs) (Fig. 8.4-2)
MtDC	Material direct cost (Fig. 8.4-2)
MtOC	Material overhead cost (Fig. 8.4-2)
MtOCS	Material overhead cost surcharge rate (s. Chap. 8.4.2)
MU	Monetary units (e. g. $) (s. Chap. 9.3.4.2)
N	Lot size (s. Chap. 7.5)
N_{tot}	Total manufactured quantity (s. Chap. 7.5)
OC	Overhead costs (Fig. 8.4-1)
OCS	Overhead cost surcharge rate (Fig. 8.4-1)
P	Power (Fig. 7.12-24)
PC	Production cost (Fig. 8.4-2)
pce	Ratio of production cost from individual times (to manufacturing cost) *pce = PCe/MC* (s. Chap. 7.7.1)
PCe	Production cost from total time units (s. Chap. 7.5.2)
PCs	Production cost from set-up times (Set-up cost) (s. Chap. 7.7.1)
PDC	Production direct cost (s. Chap. 8.4.2)
PLC	Production labor costs (s. Chap. 8.4.2; Fig. 8.4-2)
plc	Labor wage rate (s. Chap. 8.4.2)
POC	Production overhead cost (Fig. 8.4-2)
POCS	Production overhead cost surcharge rate (Fig. 8.3-3)
S_u	Ultimate strength (s. Chap. 7.9.2.1)
SDC	Sales direct costs (Fig. 8.4-9)
SHC	Shaft-hub connection (Fig. 9.3-3)
SOC	Sales overhead costs (Fig. 8.4-2)
SOCS	Sales overhead costs surcharge rate (Fig. 8.3-3)
SPDC	Special production direct costs (Fig. 8.4-9)
SSDC	Special sales/marketing direct costs (Fig. 8.4-2)
T	Torque (Fig. 7.3-2)
TC	Total (factory) cost (Fig. 8.4-2)
t_e	Total production time per piece (Fig. 7.6-2)
t_E	Piece-proportional, non-reducible part of the first time t_1 (s. Chap. 7.5.1b)
1-t_E	Time portion reducible by quantities (s. Chap. 7.5.1b)
t_i	Indirect production (idle) time (Fig. 7.6-2)
t_m	Direct machine (production) time (Fig. 7.6-2)
t_n	Piece time for the n*th* run (Fig. 7.6-2)
t_{re}	Recovery time: Time that is required for operator to rest/recover (Fig. 7.6-2)
t_s	Set-up time: Basic set-up time, set-up recovery time, set-up ***extra*** time (Fig. 7.6-2)
t_x	Extra time: Additional time that is required due to human involvement, over and above the scheduled time for a job (Fig. 7.6-2)
Var	Variable (Fig. 8.5-2)
W	Weight (Fig. 7.12-23)
yr	Year (Fig. 4.6-4)

MATERIALS:

GCI	Gray (cast) iron
MCI	Malleable (cast) iron
NCI	Nodular (cast) iron
CS	Cast steel

1 Introduction

1.1 Cost reduction – an issue in product development

This book shows how from the beginning, starting with product development the costs of a product may be lowered, or kept below a required limit.

The book analyzes more than the customary organizational measures, for example the close cooperation of product development and manufacturing, as recommended in value analysis. Methods, data and examples are shown that are directly related to product costs, including the correlation of technology and costs. Typical questions in this regard are: How to find a basic low-cost solution? What is the cost structure of the given product or of similar products? Which components of the product and what kinds of costs must be specially kept in mind? What to begin with most effectively? How to lower the costs of materials, and the production and assembly costs of the product? How to employ Target Costing for that purpose?

It makes much more sense to lower the costs right at the beginning of product development, rather than afterwards by the usual steps of personnel reduction when the costs are found to be too high.

We have dealt with these methods in our research for over 30 years. The first edition of our book, in 1985, brought out important knowledge and methods that were acquired from, and used in practice, e. g., designing to a cost goal, long before Target Costing became widely known. In the intervening time we have gained more knowledge. We know what the needs in practice are and where the weaknesses lie.

What is often missing is the motivation and courage to get rid of old practices and adapt to new ideas and ways of thinking and working. Product developers should be quite clear about the fact that they have the greatest influence on product costs. That is why they need to master their own technology, as well as the knowledge of product costs. And they need methods that will enable them to attain not only the physical objectives, but also the cost targets.

An important prerequisite for this to come about is a close cooperation of product development, production, cost control, marketing and procurement, in the sense of bringing down the "walls" between the departments (cf. Fig. 3.2-2). **Cost reduction is a team task.** Departmental egotism and refusal to share knowledge drive up costs!

If this is truly taken to heart, our experience indicates that a reduction in manufacturing costs of 10–30% is possible. Even more can be achieved by applying new concepts (Sect. 4.8.2).

Cost management today is a **necessary addition** in the development of **innovative and high performance products**, about which customers would be enthusiastic, and which fulfill the market requirements. This should be said at the beginning of a book on cost reduction. **No enterprise can survive only by reducing costs**, or by making products too costly by overengineering.

1.2 Aims of the book

The book is aimed primarily at product designers and developers. They have a great deal of influence in the early phases of product development. That is where the important decisions are made – but they cannot do it alone. Therefore this book is also written for those willing to cooperate – from production, cost control, marketing and procurement.

We recommend it to instructors, and most importantly, the students, so they may take these methods and mental attitudes into the practical world.

We intend to establish the following **learning objectives**:

- How can we develop products to predefined **cost targets** (Target Costing)? How do we establish cost targets? How do we stick to these targets?
- What types of collaboration, organization, which methods and remedies have stood the test of time in this respect? In short: How to set up **cost management** for product development?
- Which are the **most important parameters** for the product developers **that affect costs**, and what is the best way to apply them?
- Which **costing concepts** and **types of cost calculations** are important for the product developers? What should be their basic knowledge of industrial management?
- What knowledge has been gained through research and practice? What is the current **state of knowledge**?
- How can methodical design be coupled with cost-driven design? Thus, how can **innovative** and **low-cost** products be developed in **one** development process?

1.3 Structure of the book

No book that deals with how costs may be affected can be written without clarifying the term right in the beginning (**Chap. 2**). What does one understand by the term cost and **which costs are of significance for the product developer**?

Since design and development, together with product planning, have the greatest influence on the product costs, it is therefore important that the underlying reasons and the conclusions that follow, should be explained to the whole organization.

Chapter 3 shows what we understand by cost management and what the consequences are for product development work and the cooperative activities with other company divisions and with the suppliers.

A focal point of the book, describing **organizational possibilities as well as methods and tools for cost management**, is contained in **Chap. 4**. We show how they function and how they may be introduced and put to use. It is obvious that here consideration must be given to differing company sizes, product complexities and production quantities.

Since a company wants to supply user-friendly products, the costs that the user will incur with the product should also be minimized. **Life cycle costs** are a measure of user-related costs, and they are treated in **Chap. 5** from the user's viewpoint. This supplements the previous discussion from the manufacturer's viewpoint, which dealt with **manufacturing costs**.

The control of **total factory costs** is dealt with in **Chap. 6**, particularly the reduction of overhead costs through product development. As a field that has been neglected thus far, it is particularly important due to the increasing proportion of overhead costs.

Chapter 7 goes into the details of possibilities of lowering of the **manufacturing costs**. Here alternative production and assembly processes and materials are addressed so that they may be mastered. Also discussed is the management of variants, with size ranges and modular designs and other possibilities for controlling the increasing amount of the variety of variants.

The basic concepts and the advantages and disadvantages of the common procedures of **cost calculation** are shown in **Chap. 8**. The important make-or-buy decisions can be made on this basis.

Since no cost objectives can be held to in design without **concurrent cost calculations**, **Chap. 9** presents the procedures used in practice, as well as new and effective methods.

Short **examples from the practice** are shown in the book repeatedly. How the costs in a company may be reduced in a concrete fashion, is shown in **Chap. 10** with the help of two detailed examples. In addition, the various methods of concurrent calculation are explained with the example of a simple product.

The present book shows a broad palette of possibilities for a company to lower its costs in a deliberate procedure. In this regard it is not a matter of a literal application of the methods presented. They must be chosen to suit a given situation and then applied – difficult as that may be.

➔ **Methods shown here have been proven in practice.**

➔ **We wish you success!**

1.4 For an easier use of the book

Cost reduction is a complex problem. Accordingly, there are many different views, viewpoints and starting points.

The readers will find that the quickest method to start in the right direction is with **Sects. 4.5** and **4.8**, as well as the examples given in **Sects. 4.7**, **10.1** and **10.2**.

Then, if they feel comfortable with the theme, "guidelines for cost reduction" given in the Appendix provide a summary for the day-to-day work.

In addition, at the beginning of **Sect. 4.6** there is an overview in tabular form of the **measures for cost management**, including section and figure references, and in **Sect. 7.10.4** a summary of **rules for cost-driven product development**.

Finally, we have used "boxed" text to indicate important points as follows:

> ➔ Important guidelines and rules for the practical use are highlighted in the text by placing these in such "boxes".

The cost data are given in US$. We must point out that the **cost data** given in this book for parts, materials, etc., cannot be used for other purposes. They are always **company-specific** (Sect. 7.13, Cost Benchmarking) and **time dependent**, since the boundary conditions (wages, prices, etc.) change with time. Wherever cost figures are given in examples, the underlying company data have been concealed. Also, in case of materials we have used the old terminology; the Material No. (e. g., 1.0570 for St 52-3) was not used.

The **significance** of each respective **concept** is given in the Subject Index on page numbers in **heavy** type.

2 Cost Responsibility of the Product Developers

This chapter will explain some cost concepts relevant to product development. Then, the influence the company departments participating in product development have on how costs originate in a company will be investigated. This will show that product development has the greatest significance in company cost management. However, for the long-term success of a company, innovation should not be neglected for the sake of costs.

2.1 What are costs?

In our society, the very existence of human beings is tied to a continual outlay of money. Food, clothing, and shelter are all are basic needs that will always need to be satisfied anew through expending financial resources. For this reason, each of us is familiar, from our own experience, with the problem of how costs originate.

In economics, **costs** (see Sect. 8.1) are generally defined as consumption of goods for company's output, expressed in terms of money. In this context, goods may be material, energy and company facilities, as well as labor, information, or the utilization of capital and the rights of others, e. g., intellectual property rights. For a company's output, creation of goods includes **providing products** or **rendering services**. Thus, we always aim for so-called **added value**, which means that the result of the goods used has more value than the sum of the incurred costs.

In a company, the costs and the possibilities of reducing the costs can be viewed from a variety of perspectives. From the aspect of efficient product development, the costs that are of interest here are those incurred by the products. In this regard, a classification of costs (as shown in **Fig. 2.1-1**) is useful. The basic costs that originate with the product itself are the **manufacturing costs** (*MC*, cf. Chap. 7), that is, those costs that can be assigned directly to the manufacturing process. Essentially, these consist of the material and production costs for the product. In addition, there are costs that cannot be directly assigned to the product manufacture (e. g., **administrative costs**). They are combined with the manufacturing costs to form the company's **total costs** (*TC*, cf. Chap. 6). The total costs, in turn, contribute to the **lifecycle costs** (*LCC*, cf. Chap. 5) and are reflected in the product sales price.

The lifecycle costs are costs that accrue to the product user, and are the sum of all costs associated with purchase, use, and disposal of the product (cf. Fig. 5.1-5) They may be roughly classified into the following types of costs:

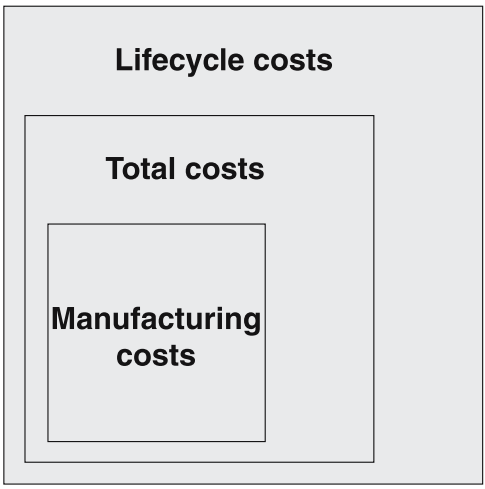

Fig. 2.1-1. Classification of costs

- **Initial costs**, which consist essentially of the initial price of the product. The resale price of the product at the end of its useful life could be subtracted from the initial cost.
- **One-time costs**, for example, costs for transport, installation, startup, personnel training, and disposal.[1]
- **Operating costs**, for example, ongoing costs for energy, operating materials, and their disposal, as well as wages for service personnel.
- **Maintenance costs** for servicing, inspection, and repair.
- **Other costs**, for example, capital costs, taxes, insurance, and breakdown costs.

For the user, lifecycle cost is the criterion by which a product's economic efficiency can be measured. This strictly economic view of a product's cost/benefit ratio is increasingly important in the field of capital goods. The lifecycle costs are a vital selling point that can be used to provide a contractual guarantee to the customer. In the consumer goods sector, other factors often play an important role in making purchase decisions (e. g., simply the price). It is less common to evaluate such products strictly according to their expected lifecycle costs, although this aspect is also important (Fig. 5.2-1).

There is a fundamental **contradiction** between the interests of the **product user** and those of the **manufacturer**. The manufacturer's primary interest is the maximization and assurance of the company's **profit**. Put simply, profit is the difference between the product's selling price and the total cost of product realization. That is why the manufacturer strives to reduce the company's total costs as much as possible, by developing cost-effective products and rationalizing company-internal processes. However, beyond the total costs, the manufacturer is also interested in

[1] According to the Take-Back Law in Germany, these costs may have to be covered by the manufacturer.

the product's lifecycle costs. In this way, the product's market competitiveness (i. e., the customer's interest) is clearly improved, as long as the company is not forced by regulatory requirements e. g. to address product disposal.

There are a number of ways to classify the total costs at the company level, which are significant in cost management. There is the fundamental classification according to **cost types** (cf. Sect. 8.3.1), for example, material costs, personnel costs, or capital costs. Cost accounting further breaks down costs into **direct costs** and **overhead costs** (cf. Sect. 8.3.2) as well as **fixed costs** and **variable costs** (cf. Sect. 8.5). As shown in **Fig. 2.1-2**, these are not "other" costs, just different ways of looking at the total costs in the company.

Direct costs are costs that can be assigned directly to so-called cost units (cf. Sect. 8.3.3). By **cost units** we mean the company's individual products or service activities. Typical direct costs are production material costs or production wages (direct labor). In contrast to these, the term **overhead costs** includes those costs that cannot be thus assigned. Examples of such costs are administrative costs, officers' salaries, CAD costs, heating costs, etc., which cannot be assigned to a specific cost unit.

Furthermore, costs may be designated as fixed or variable, according to whether they are dependent on the company's workload or production quantities. Examples of variable costs are material direct costs or direct labor, which accrue only when production takes place. Fixed costs such as rent, depreciation, or salaries are, as a rule, independent of the company's workload.

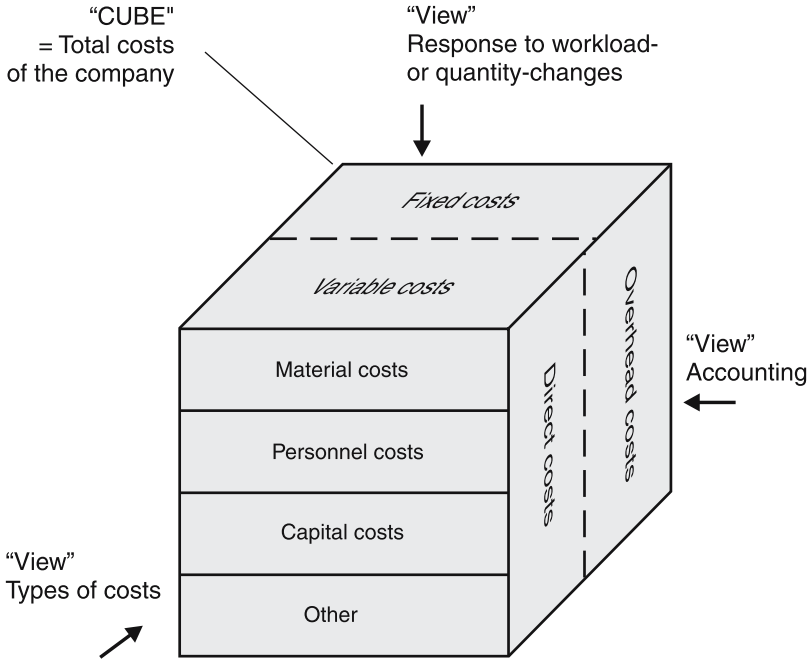

Fig. 2.1-2. Various views of the total costs of a company

2.2 Who affects costs in a company?

The aim of a company's activities is to increase and ensure its profit, (i. e., its return on capital). Since profits equal the earnings less the costs, there are basically three approaches to maximizing profit, as shown in **Fig. 2.2-1**. These are generally used in parallel.

The first approach is to **increase the company's earnings**. Strategies to achieve this include offering market-driven, "better" products, shorter supply times, and improving sales and customer service. **In particular, companies in countries with high competition exist by offering innovative products** [Gau00]. This must be emphasized at the very beginning of a book on cost reduction.

The second approach is to **reduce the total costs**. This can be the result of, for example, **rationalizing the product realization process**. This concept refers to all the measures that make the company operations more efficient, thereby reducing the costs of manufacturing a product or of providing a service. Other measures, such as computerization, production automation, reducing personnel costs, providing faster order fulfillment, or reducing inventories can also help in this regard.

Parallel to that, the company must follow the strategy of **developing cost-effective products**. This includes developing product concepts that are economical

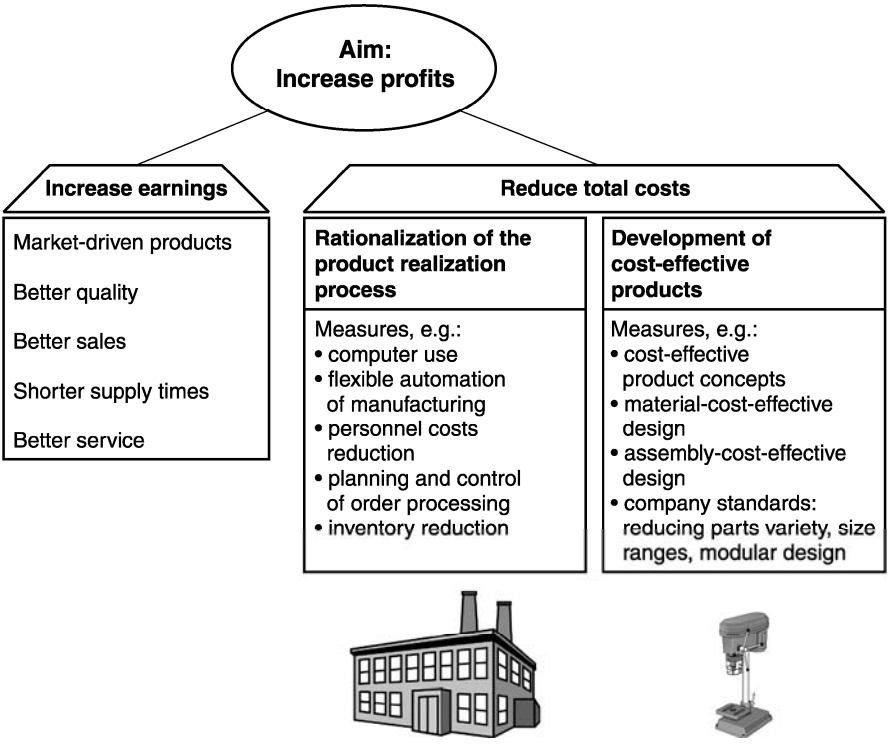

Fig. 2.2-1. Alternatives for increasing a company's profits

from the ground up; reducing the variety of parts; developing shape designs that contribute to economical production, assembly and materials; and company-internal standardization. In contrast to the rationalization measures described above, the development of cost-effective products requires cost reduction steps that work only in the mid- to long-term.

How do these three strategies fit into company operations to ensure higher profits? To answer this question, we look next at the five most important phases (Fig. 2.2-2) of the product lifecycle:

- **Decisions** about the product are made during project planning or product planning, and then forwarded to either the customer (on basis of a delivered offer) or to a responsible person within the company. In the making of these decisions, there are basic differences.

  In the case of **project planning** originating from a customer request, a special product or plant concept is usually initiated. What is important here is a very precise interpretation of the customer requirements, as well as being able to present possible solution alternatives along with their associated cost effects. The customer's technical requirements (e. g., function or performance, weight, size, etc.) are addressed by approximate computations and the design process, and the costs are estimated.

  Project planning results in a bid or an offer. In spite of what might be very short time spent on project planning, there must be evidence that the cost target can be held to before the bid is released. Therefore, only known elements (functions, parts, and their costs) are generally used in project planning. Thus, when the order comes in, it can be worked on as a variant or an adaptive design.

  In contrast to the above, **product planning** pertains to an internal decision on whether a new product or plant should be developed for a number of customers. Customer inquiries are anticipated, from which profitable orders may result in the future. In this regard, the questions are:
  – What types of problems will lead to customer inquiries in the future?
  – What types of solutions will result in additional profitable orders?

  Product planning is long-term focused, is strategically aimed, and is the result of an internal decision process, frequently for a new or an adaptive design. The degree of novelty in this decision, regarding the market as well as the product and the technology, raises the entrepreneurial risk.

  Product planning starts with facts about the company and its milieu. The first step is to determine which areas are to be searched for product ideas, and analyze the potential of the enterprise. Then, the product ideas are developed and taken through a multiple-step evaluation process. Strategic product decisions in this regard cannot generally be made right away, nor strictly planned. They require a longer, continual preparation during which the organization's internal strengths as well as available external opportunities are identified and evaluated, and the possibilities for action are considered [Ger02].

  In making decisions during product planning, it is important to bear in mind the different interdependent systems, the markets, customer groups, distribution channels, demand structures, legal restrictions, manufacturing processes, etc. These should be combined, along with the company objectives, into a logical

entity [Mai01]. Knowledge of the features of the various systems and their interdependence is a prerequisite for product planning. The resulting decisions must be portable and possible objectives must be attainable.

- **Product development** includes all the phases which, following the decision to proceed with development, lead to the start of regular production. In the development process, the product properties must be defined such that its use by the customers and its production meet the criteria set during project planning. The aim of product development is to compile the documents pertaining to production and use.
- In **production**, the actual product takes shape, largely following the guidance from product development.
- The product is bought by the customer for its **utilization**. Project planning, product development, and production are, therefore, oriented toward the benefits the product will provide the potential purchasers [VDM97]. This implies an orientation to user benefit!
- The **disposal** of the product at the end of its use completes its lifecycle.

Costs arise during individual lifecycle phases that add up to the lifecycle costs over the product life (cf. Fig. 5.1-3). These can vary widely according to the type and use of the product. The problems associated with this will be discussed in detail in Chap. 5. At this point, the even more important question is: Exactly when during the product lifecycle are the decisions made regarding a product's special attributes, thus adding more to the costs?

Figure 2.2-2 shows schematically the possibilities of influencing costs, and how the costs increase with the successive life phases of a product. These two curves run in opposite directions! In the beginning phases, in which we have the most influence, the least is known about the future costs. It is obvious that during project and product planning the costs of a vaguely defined product are known only very roughly, whereas the possibilities of influencing these are the greatest. At the beginning of the product development process alternative paths can be chosen. At its end the lifecycle costs of the product are largely set, even if they are still not known. In the phases of production, use and disposal, still another cost optimization can be carried out. This optimization is of the individual processes, based on the development outcome. If an automobile motor is developed then there is little leeway as far as manufacturing and operating costs are concerned. By a clever choice of production processes, or with especially cautious driving, one could still save on costs. The largest part of the lifecycle costs, however, can be changed little, since they can be influenced only at the beginning of the lifecycle. This is equally true as far as advantage by innovation or the alignment of the product toward customer-use is concerned. These statements hold for new designs. In case of adaptive and variant designs, the possibilities of influencing costs are fewer (cf. Sect. 4.8.2).

We cannot emphasize enough the importance of the early life phases for the product's success. Any mistakes made here can be corrected later only with great effort, if at all. Thus we can realize the importance of **early cost identification** (cf. Chap. 9). The following should be brought to the attention of traditional product developers, who tend to be rather technical.

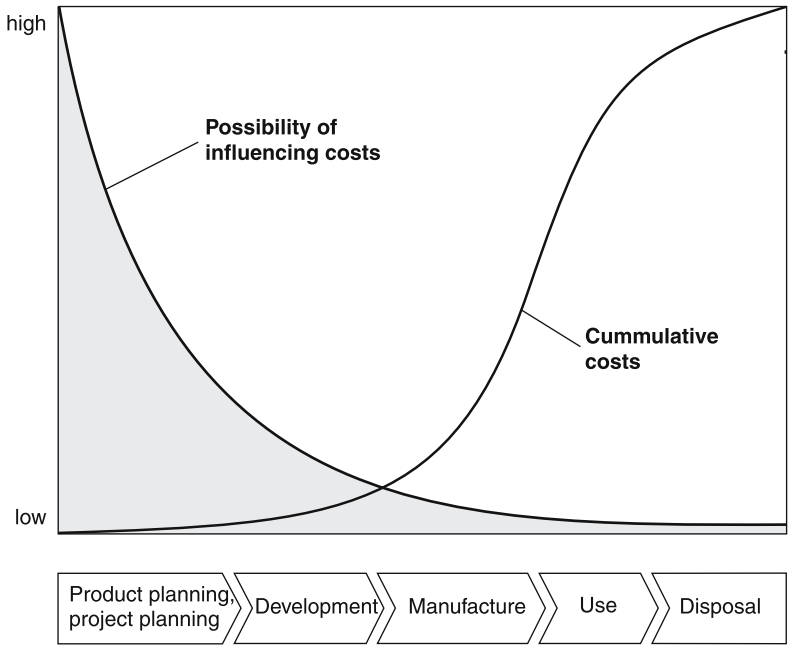

Fig. 2.2-2. Possibilities of influencing and establishing costs over the lifecycle of a product: The "dilemma of product development" (an example of a new design)

- **Each technical commitment also** represents **an establishment of costs.**
- This establishment of costs must be checked **concurrently in the product development process** (the cost numbers should be available when a technical decision is made). Otherwise, the product can become too expensive, which will require time- and cost-intensive changes (cf. Fig. 4.2-3).

From practical experience, the "**Rule of Ten**" was formulated, which conveys the idea of the exponential growth of costs over the life phases of the product. The later the changes are made, the more expensive they get. For example, a technical change that costs 1 $ at the task clarification stage will cost 10 $ during designing, 100 $ at the production planning stage, 1 000 $ if made during production, and 10 000 $ after shipping!

Product planning, project planning, and product development are highly significant for the later life phases of a product. Indeed, who makes the basic decisions during these activities? **Who really determines the future costs of a product?** We emphasize that the responsibility lies within the management, marketing, product development, and production functions of a company during the planning and development of a new product.

The **management** of the Company determines the company policy. They are obviously also responsible for deciding on the basic direction of the company's

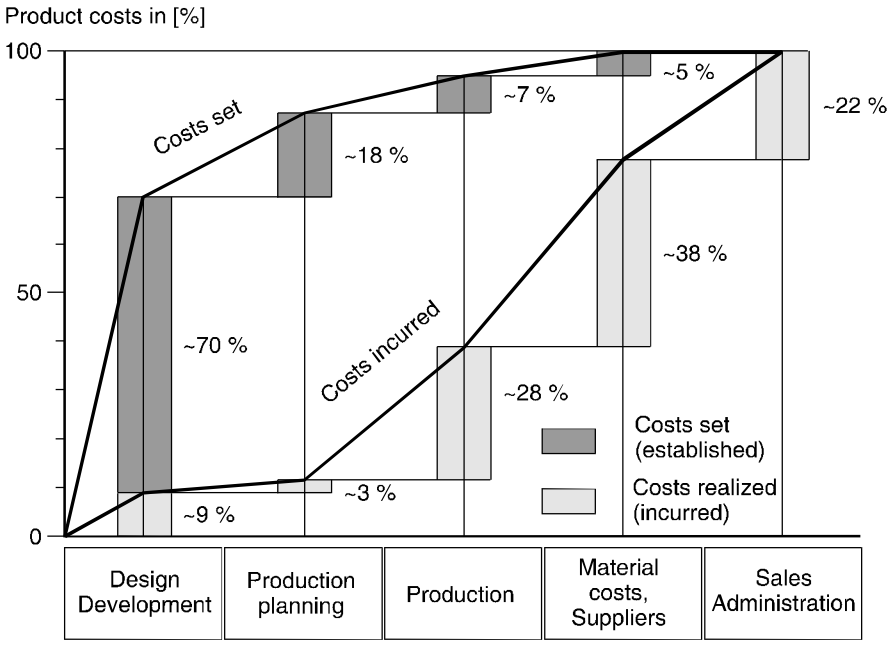

Fig. 2.2-3. Costs set and costs incurred in different departments [VDI87, VDM95]

product line. By deciding on a given product or a product line, they also determine its essential costs, even if they are not yet known.

Technically competent **sales** and **marketing** departments are links between the market, the customer, and the company. Thus, their job is to analyze the wishes of potential customers and, on basis of this knowledge, initiate the planning process for new products. Including sales and marketing, and thus the customer requirements, in product planning, project planning, and product development is a key to the product's success. These departments also gather cost objectives from the market and, thus, provide concrete cost limits in the product development process.

The **product development** department is the "unit" – the body responsible – for the project planning as well as the development processes. Here, the information coming from different areas is converted into a marketable product or product concept. One of the most important tasks of product development is to bridge the gap between the customer's dream product, the planned technology changes, and what is technically and economically feasible – a tough job, indeed! When the design is complete, the manufacturing, operating, and disposal costs are largely fixed. Thus, it can be said that product development has the greatest direct quantitative influence on a product's manufacturing and lifecycle costs (cf. **Fig. 2.2-3**).

A company's largest costs arise in **production** and **purchasing**. Therefore, these merit the greatest attention in the rationalization process. Production and purchasing should be integrated into product planning, project planning, and development of new products right at the beginning because optimizing part production and assembly processes is easiest and most effective during the shape design