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Jouni Juuti

Framework for Managing Activity-Based Optimisation of Order-Delivery Process

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Department of Industrial Engineering and Management, Institute of Production Engineering, Tampere University of Technology
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ABSTRACT

In spite of the new elements included in competition today, traditional sources of competitiveness cannot be overlooked. In practice, development of these components is poorly structured. An understanding of the similarities and differences between the relevant isms and fashionable trends requires a thorough study.

Development can be focused on products, operations and/or resources. This study focuses on operations and on the development of operational performance. Despite the availability of various methods to develop the order-delivery process, a clear need exists for methods which help to identify the primary development objects in the order-delivery process and to define the concrete development actions needed.

The main object of this study is to develop a method to identify development actions on the activity level to achieve a comprehensive optimisation of the order-delivery process. Optimisation on the activity level contributes to a stabilisation of operation on the process level. Correspondingly, optimisation on the activity level may require a reengineering on the task level. The second object is to provide a description of the general structure of development.

The study applies a constructive research approach and is divided into five main parts. The first deals with basic concepts of development. The second reviews the existing approaches to problem analysis in development work. The third part presents the model developed. The fourth part contains the practical validation of the research result and the final part contains the discussion of results and topics for further research.

The main result of the study is the development of a method which enables the systematic inclusion of goals set on higher levels and a comprehensive analysis of operations, as well as proposes concrete development actions. The method presented in this study for structuring the ideas for development has proved very usable.

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Words can never express the gratitude which I feel for my nearest and dearest, my wife Pirjo and my daughters Tiina and Eeva, for their generous support and understanding.

The research report now in your hand is the result of an interesting and thought-provoking journey through the challenges and variabilities of corporate business operations.

Tampere, April 2005

Jouni Juuti

CONTENTS

DEFINITIONS

The following definitions and terms are used in this thesis. Definitions can only be general; some of them are valid for the purpose of this thesis only.

Activity is an operation of a certain size.

In **activity-based model**, the process studied is described by means of activities.

Actual value of product features is the value of product features after product has been realised (what remains of planned value in product features).

Actual resource amount corresponds to the amount of resource, either variable according to consumption or fixed, which has caused costs in the entity studied.

Actual resource cost is defined on the basis of the actual unit cost of resource and the actual resource amount.

Actual resource utilisation measures the amount of resource needed as a share of the actual total amount of resource.

Added value of realisation is limited to include the share of added value which is generated in the context of product realisation, the phase when the product and its features are made concrete.

Availability of fixed assets (machines) as an indicator shows the proportion of planned working hours during which the resource may be used.

Basic operation generates basic products or basic and support products.

Basic product satisfies customer needs.

Work done by **basic resources** adds value to the product immediately. Consumed amount of basic resource depends on the amount of realised products.

Bottleneck resource is a resource which constrains operation throughput. Queue time occurs before a bottleneck resource.

Buffer time is the time spent by the product in safety, surplus and decoupling buffers (does not include synchro time).

Competitive factors describe factors with which the company's products compete on the market.

Core competence means any skill, knowledge or capability which may be regarded as being of high level in comparison to the company's competitors.

In **corrective improvement** the main weight lies on reducing the variability of the development object which is due to common causes.

Critical path is the chain formed by the interdependent basic operations whose lead time determines the lead time of the upper-level operation studied.

Customer value of a product is the amount buyers are willing to pay for what a company provides them.

Cycle time (resource viewpoint) is the length of calendar time which the resource studied (machine) works with products.

Degree of utilisation describes the number of planned working hours. The maximum degree of utilisation is the number of working hours available.

Delivery time (customer viewpoint) is the length of calendar time which elapses from the customer impulse (such as an order or delivery call) to the moment when the product is delivered to customer as agreed.

Development objects of developing operational capabilities are the elements of operational business; products, operations and resources.

Disturbance time includes occasional periods for problem solving, maintenance and product repair.

Effective, value-added **operation** increases product’s value.

Efficiency of time consumption of operation measures the share of value adding working time calculated from the lead time of the corresponding operation.

Idle time is time comparable to calendar time, during which the operation is not being implemented; during idle time the resources consumed in the operation are not designed to work within the operation, i.e., nothing happens.

By **improvement** operations under control are developed in small steps.

Internal reliability of delivery of an activity is used to measure the inherent reliability of delivery of the operations included in the activity, excluding the effect of external factors.

Lead time (operation viewpoint) is the calendar time used to complete the operation. The lead time of an operation is determined on the basis of the critical path formed by lower-level operations. The lead time of an operation may be defined by analysing the throughput times of single products.

Level of development defines the way of development depending on the degree of change sought after, or on the difference between current state and target state.

Machine work method efficiency measures how much added value the machine can achieve through working.

Management of resource costs as an operational success factor pays attention to the unit cost of resources, or the economy of resources (prices paid for resources) and to the resource amounts available (resource adaptation).

Move time is the time spent in moving products inside an operation.

Non-value-added, non-effective **operation** does not increase product’s value.

Offered value of product corresponds to the company's conception of the customer's needs and expectations.

Varying size **operations** generate products.

Operation adaptability describes operations ability to adapt to products adaptability.

Operation effectiveness is based on its capability to increase product’s value.

Operation efficiency is determined by the ratio of the added value of operation and the corresponding operation cost.

Operation maturity describes the progress of process development.

Operation structure describes the entity formed by the operations necessary for the generation of the products studied, and by the links between these.

Operational capability describes the capability which the object under study has of reaching the performance expected of it.

Operational success factor describes the goal-oriented operational capability of the order–delivery process.

Operational quality of an operation may be assessed by examining in terms of operation effectiveness and operation efficiency.

Operational quality as an operational success factor is understood as the capability of doing effective things efficiently.

Optimal resource amount is the quantity of a resource which has an equal value, is capable of the same performance, may be implemented without radical charge and is optimal in terms of what is expected of the resource amount.

Optimal resource cost is formed as the result of the optimal unit cost of resource and optimal resource amount.

Optimal resource utilisation measures the amount of resource needed as a share of the optimal amount of resource.

Operations **optimal value adding working time** carries out only absolutely necessary (optimal) amount of value adding work to the operations corresponding share of critical path.

Optimality of resource amount or Optimality of resource utilisation estimates the degree of optimality to which the cost-causing resource amount is utilised.

Optimality of resource cost is determined on the basis of the optimality of resource economy and the optimality of resource amount.

Optimality of resource economy measures the share of the optimal unit cost of resource of the actual unit cost of resource.

By **optimisation**, one development object (product / operation / resource) at a time is developed to as good a level as possible within the constraints posed by the other two.

The concept of **performance** describes an individual's rate of working. Performance is the ratio between the standard performance and the individual's actual work performance.

Planned value in product features contains the values which have been planned in the features of all product sorts.

Presence of personnel is used to measure the probability of availability of the personnel as a basic resource.

Proactive improvement strives for an awareness of problems before they become actual.

Process consists of one activity or of a net formed by several activities.

Process map examines the connections between processes in a value net.

Product is the object of operations.

Product adaptability describes how much basic product adapts to the customer needs.

Product architecture both describes and determines the products, which the product studied (the end product offered to customer) consists of.

Product maturity describes the degree to which a product has been commercialised.

Different **product sorts** (physical product, information, service) define the product.

Product value describes the usefulness of the product in the satisfaction of individual or collective needs.

Productivity measures the efficiency with which the resources create products in carrying out operations.

Queue time is created when a product queues for processing by the resource which implements the operation (while the resource is otherwise occupied). Queue time does not include setup time, which is defined separately.

Reengineering means a radical, one-off improvement of the performance of the object being developed.

Resource adaptability describes the capability of resources to correspond to different goals valid at different points in time.

Resource cost may be defined as the result of the unit cost of resource and the resource amount.

Resource economy is based on the comparison of prices paid for the resource (unit cost of resource).

Resources may be divided into **resource sorts**: personnel, energy, tied-up capital in its various forms and support products.

Resource structure describes what organised resources are consumed in the operations studied and how this is done.

Resources are consumed in order to realise operations.
Role of operation is determined by the role of the products achieved by it.

Role of product is determined on the basis of how it is linked to the product offered to the customer.

Role of resource is determined on the basis of how it is linked to the realisation of the product.

Saving potential based on optimal resource cost consists of the difference between actual resource cost and optimal resource cost.

Saving potential based on resource economy is determined as the difference between actual resource cost and the resource cost based on optimal unit cost of resource.

Saving potential based on resource utilisation is formed as the difference between the actual resource cost and the resource cost based on the optimal resource amount.

Setup time, in this context, is the part of throughput time during which a resource which processes the product is being set up.

Speed as an operational success factor means the speed of implementing the company's core processes, the management of process lead times.

The aim of **stabilisation** is to bring the object being developed under control so that its performance is predictable.

Standard time of work corresponds to the time which a skilled operator well versed in this work will need to carry out certain work, when applying the normal performance, a familiar method and in standard conditions, including assistance and preparation time.

Support operation only generates support products.

Support product supports the basic product in the short and long term.

Support resource participates indirectly to the realisation of products. Consumed amount of support resource depends on the (calendar) time.

Synchro time is caused when the product is waiting. The operation cannot be implemented because all the products needed in the implementation are not available at the time desired.

Tasks and work stages describe action on a detailed level.

Theoretical efficiency of time consumption corresponds to optimal value adding working time.

Throughput time (product viewpoint) is the calendar time for a product to pass through the operation.

Unit cost of resource describes the price paid for the unit used to measure resource consumption.

Usefulness of current assets measures the probability with which an INPUT product acquired (for storage) will be available to the operation which needs it.

Utilisation of working time in manual work is the share of planned working hours, or the work period, which is used for working, in contrast to events which are repeated on different days, i.e., assistance time.

Machine **utilisation rate** indicates the share of planned working hours used by the machine for working.

Value-added, effective **operation** increases product's value.

Value adding throughput time is the part of throughput time during which the product is processed.

Value adding working time is the total time used to process the product from basic resources in the operation studied.

Value destroying operation decreases the value of the product.

Value net is formed by interconnected operations. The value net is based on the product offered to the customer. The actors included in a value net operate in partnership; among other things this means that the performance of the value net is improved and optimised as one entity.

Value of assumed image is the expected value of company's image**.**

Value of basic product is defined by the customer who uses the product to satisfy his needs.

Value of purchases as part of the value offered, is based on the concept utilised value of purchases.

Value of support product is based in the short run on its usefulness for the realisation of basic products and, in the long run, on its usefulness in attaining strategic goals.

Variability includes everything that causes a system to deviate from a regular, predictable behaviour.

Wait-to-move time is understood as the time spent in complementing a moved or complemented batch.

Different **work sorts** processes different product sorts.

1 INTRODUCTION

1.1 Background

In spite of the fact that competition today includes new elements, thanks to the potential brought by such factors as global networking and information technology (IT), traditional sources of competitiveness cannot be overlooked. Maintaining competitiveness requires that all its components are continually developed, since staying in the same spot in fact means moving backwards. The pace of development and the degree of ambition as regards goals vary from case to case depending on needs and opportunities. In some cases, performance and competitiveness may be sufficiently improved by stabilising a number of selected development objects. The objects brought under control by stabilisation should continuously be improved and, if necessary, revised from time to time through radical, comprehensive reengineering projects.

At the start of the 2000s, the goal of production-related development, the "good factory", is no longer an unambiguous concept in the way it was in the 1980s and some of the 1990s. Earlier, the concept *good factory* almost invariably meant high productivity achieved by means of advanced methods and a high utilisation rate of resources. High productivity also partly enabled low unit costs of products. In addition to traditional productivity, today's *good factory* must, in line with established goals, be capable of controlling the quality, cost and speed of both product and operations.

The development projects in Finnish mechanical engineering companies do not always support a goal-oriented manner of doing business. Looking at them it is difficult to avoid the feeling that, as regards development, "speed is more important than direction". The controversy inherent in the situation may be supported by the inability of those who approve development and investment projects to combine the defined strategies with concrete, floor-level development and investment projects. It may also be the case that the company's ultimate goals are not presented sufficiently clearly by the company's top management. If so, those responsible for production development will work towards their own goals, and these may be in conflict with higher-level goals and lead to partial optimisation. At times, development seems to be based on fashionable patent solutions without an analysis and awareness of actual operational goals and of the problems related to implementing these goals. It is also possible that the start of systematic development has stumbled on a lack of necessary know-how: ignorance of what to do and in what order.

The organisation Technology Industries of Finland (formerly the Federation of Finnish Metal, Engineering and Electrotechnical Industries) has been strongly involved in the development and launching of suitable development tools for Finnish mechanical workshops. In the 1980s, the quality circle thinking was strongly promoted, as well as a Finnish version of the Japanese Just In Time (JIT) production philosophy. In the 1990s, investments were made, among others, in continuous improvement and the LEAN philosophy. While excellent in themselves, these projects have unfortunately not always awarded the results expected.

In the development of business activity, isms and fashionable trends have traditionally received plenty of attention. The gaining of an overview in this field has not been facilitated, to say the least, by the fact that each school has adopted a terminology of its own. An understanding of the similarities and differences between the schools has required a thorough study.

What is it, then, that should be developed in a company with business goals? And how should it be developed? This study aims at finding the answers to these frequently-heard practical questions, within a certain limited scope. As proven in chapter 5, a clear need exists for methods which help to identify the primary development objects in the order–delivery process and to define the necessary concrete development actions. Especially at the initial stages of development, approaches are needed which allow the systematic conversion of higher-level goals to practical development actions which support the upper level. In the manner of a rough working model, the method for identifying development objects should guide the process of identifying the development objects and implementing development actions. The method should allow a comparison between the various development objects and be capable of assessing their impact on the desired end result.

Since business activity is based on satisfying customer needs by means of products offered to the customer, the product may be regarded as the primary development object of operational business activity. The product forms the interface between the customer and the business operator. Products are brought about by means of operations of various levels. The carrying out of operations consumes resources. The product dictates which operations are needed, and the resources to be consumed are in turn defined by the operations.

This study focuses on the development of operational performance in general. Due to the opportunities awarded by new market areas, customer segments and products, the significance of operational excellence may be overlooked. According to Ashton, Cook and Schmitz, before companies look for growth from new customer segments and/or from new products, they should utilise the potential still hidden in existing products and customer segments. They present their view in the form of a Strategic Pathway: "First, *protect* your existing business. After that, *penetrate* further into existing market segments with existing products or upgrades. Then, *extend* the business by creating new products for existing segments or by entering new segments with existing products. Finally, *diversify* into new markets with new products." The implementation of the later stages in the pathway also requires operational excellence: “The operational excellence at the business-unit level is fundamental for success. If a company's existing business does not have a firm foundation of operational excellence, any initiatives to protect that business, to further penetrate existing markets, and to extend and diversify the business are likely to be mediocre at best and disastrous at worst.” (Ashton et al., 2003)

In the 1990s, a great deal of attention has been given to business development relying on process-based approaches. This type of approach may often feel justified because it studies entities important for the customer and the business and avoids partial optimisation. Primarily, process-based management has focused on the renewing of processes. However, the success rate of process reengineering projects aimed at a comprehensive change of the operating model is only about 30%, according to reports (see, e.g., Tekes, 1999, p. 26). This implies an over ambitious level of development. Approaches are needed which are process-based but enable a more robust level of development.

This study focuses on the development of order–delivery processes designed to realise products. The term order–delivery process describes a range of operations which are started by the customer impulse (order) and end up with the creation of the product and its delivery to the customer. Although the order–delivery process serves as the primary focus of interest, the methods developed may also be applied to other processes and to business operation on a more general level.

1.2 Objectives and scope of research

The **research problem** falls into two parts:

1. In practice, development of operational performance is very unstructured.

2. There is a lack of methods to identify development objects which are suited to the comprehensive development of order–delivery processes and which

   - systematically include the goals set on higher levels,
   - comprehensively analyse operations, and
   - propose concrete and sufficiently detailed development actions.

The following **research hypothesis** is derived from the research problem:

It is possible to develop a method to support the development of the operational implementation of the order–delivery process which

- *implements the strategic goals of the company,*
- *is based on systematic, objective analyses,*
- *proposes concrete development actions and*
- *is process-based.*

On the basis of the research problem and the research hypothesis, the following **goals** are defined for this dissertation:

1 Description of the basic concepts of development.

2 Development of a method to identify development actions which optimise comprehensively the order–delivery process and

- in which the development goals are derived from higher-level strategic goals,
- which applies objective analyses and leads to the same end result independent of the analyst,
- which proposes concrete and sufficiently detailed development actions and
- which is process-based.

1.2.1 Requirements for the method of identifying development objects

Content of the method:

To analyse the performance corresponding to the operational success factor derived from the competitive strategy of the organisation under study. To identify the development potential linked to the optimisation of the existing mode of operation and the factors preventing optimal performance.

Goal of the method:

The goal is to improve the result of business activity by identifying and implementing development actions on the operational level which visibly promote the implementation of strategic goals set for the business activity.

A crucial issue for the development of operation is the purpose of the business activity and the goals defined for it. The goals set for a business are affected by its many stakeholders with their individual goals. The development model aims at safeguarding the systematic progress of development by defining a continuous path to connect the overall business goals and the individual, floor-level development actions.

One of the goals defined for the method to be developed here is that it should enable the mapping of areas to develop as rapidly as possible after the higher-level goals have been set or redefined. According to a definition of operational quality, to be presented below, the main focus of the first stage lies in the identification of the correct development objects, while the next stage focuses on the development methods used and their efficacy. The aim is that development finds its proper level during implementation. As shown later in chapter 7, if the prerequisites for operational improvement do not exist due to the great variability in operation, the model will guide development towards the necessary stabilisation of operations. On the other hand, if the performance improvements attained through optimisation are insufficient and the prerequisites for a more thorough reform of the operating mode exist, the model will help to identify that situation.

The method for identifying development objects developed in this study is suitable for use both in-house and by external experts. When used by external experts, the method supports both process and expert consulting, with the main weight placed on the problem-solving process.

Depending on which operational success factor is selected as the basis of the goal-oriented mode of operation, the method looks for a concrete answer to one of the following, alternative questions:

What measures are used to optimise the quality of operation of the order–delivery process studied?

or

What measures are used to optimise resource costs?

or

What measures are used to optimise the speed of the order–delivery process studied?

The definition of *optimisation* applied in this study is as follows:

By optimisation, one development object (product / operation / resource) at a time is developed to as good a level as possible within the constraints posed by the other two.

1.2.2 Scope of research

Chapters 2–4 of this report define the scope of the later sections which contain the structure developed during the study. Chapters 2–4 present an overall structurisation of development and definitions of terminology and concepts.

Development object

On the general level, the development of operational business activity may focus on *products, operations* or *resources* and corresponding structures. Since the product is the object of operational business activity, it may be regarded as the primary development object. This study is limited to studying the development of operations. The product is regarded as given and stable. The functionality or usefulness to customers of the products is only examined to a limited extent. One of the grounds for the development of operations may be defined as the fact that the success factors built into operations are often much more difficult to copy than the features which enhance a product's competitiveness (i.e., success factors are more difficult to copy than competitive factors).

Since an individual company is rarely capable of controlling all of the expertise needed in its business activity, a shared value net is formed by companies which possess different types of expertise. When looking at business activity from the process point of view, it is possible to identify in the value net the following general key processes: the customer, the product and the *order–delivery processes*. In their competitive strategies, the companies sharing a value net weight these key processes and the corresponding domains of core expertise according to their value base. This study focuses primarily on developing the *operational capability* of order–delivery processes for physical products. Operational capability describes the capability which the object under study has of reaching the performance expected of it. The principles and development models presented may also be applied to other key processes.

Operational level

In development, the scope of the desired change needs to be understood. The development of operational capabilities may be focused, for example on individual tasks (such as machining), on an activity (such as assembly), on a key process (the order–delivery process) or on a business entity formed by core processes, i.e., the value net. In this study, development actions are examined on the activity level, since activities as development objects are of a manageable size, understandable and concrete. By affecting activities it is possible to affect what actually happens in a company. In this context, the orientation on activities means an approach which monitors an actual process and a focusing of the development actions on individual elements within activities.

Level of development

Development as a concept is very broad in scope. The development of production may vary from the implementation of mistake proofing (poka-yoke) to a definition of strategic success factors in the value net. Development may be roughly divided into strategic planning and the development of operational capabilities. The development of operational capabilities focuses on the development of performance in line with strategic plans. The question often asked in connection with development is:

Will evolution be enough, or do we need a revolution?

What is the size of the change required, will a sufficient result in view of the operational goals be achieved by improving the existing mode of operation (evolution) or is a completely new mode of operation (revolution) needed? This study focuses on optimising current operation on the activity level. Optimisation on the activity level contributes to a stabilisation of operation on the process level. Correspondingly, optimisation on the activity level may require a reengineering on the task level.

Figure 1.1 shows the scope of this study in terms of the development object and level of development. Activities as operations are the development objects of Activity-Based Optimisation (ABO). The order–delivery process is developed by optimising the performance in accordance with the operative success factor on the level of activities.

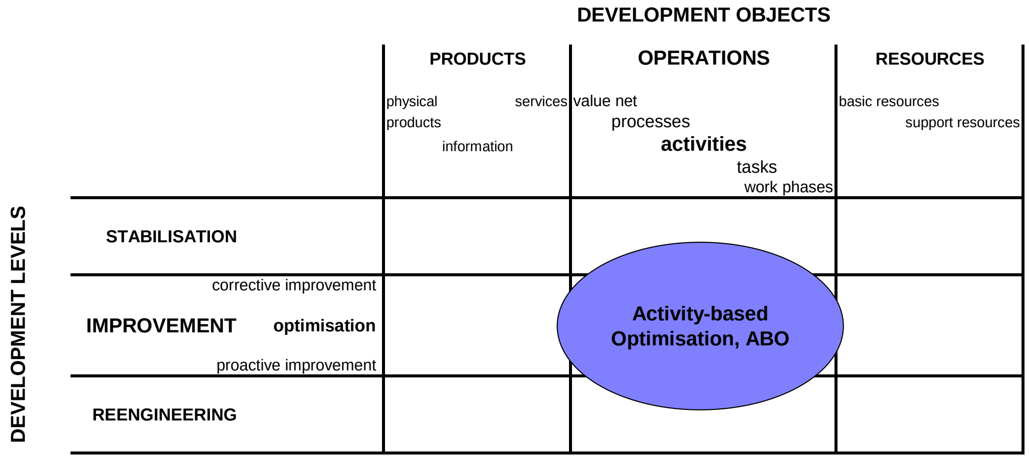


Figure 1.1 Scope of research.

1.3 Research approaches

The research approaches have been selected on the basis of the research problem and the research goals. In selecting the approaches, the examination was limited to those applied in business economics and industrial economics. Because the main focus of this study lies on developing a method for solving practical management problems, the dominant approach applied in this study is a constructive approach.

In Finland the constructive approach was brought into the business economics research community by Kasanen, Lukka and Siitonen (Kasanen et al., 1991). According to them, construction means an entity which provides a solution to an explicit problem. The aim is to reach a desired end state, setting out from a given original state. According to Kasanen, Lukka and Siitonen, constructive research may be seen as a form of applied research. Applied research is characterised by the production of new knowledge which is directed at an application or objective. Defined by its starting-points, the constructive approach consists of a development of problem-solving methods related to management. The constructive approach emphasises creativity, innovation and heuristics. In particular, innovation serves as the basis for constructing the problem-solving method, and heuristics is manifested in the stepwise development and testing of the solution. An essential additional expectation is that the functionality of the solution should be tested in reality. The constructive approach starts with the original problem to be solved and aims at solving it or developing a solution method. The starting-points of a constructive study lie in a practical situation experienced as problematic, and the end result may be used in solving the problem (Kasanen et al., 1991).

1.4 Structure of the study

This study is divided into five parts.

PART I

Chapters 2, 3 and 4 present a general structurisation of development. Chapter 2 examines the elements of operational business activity on a general level and specifies the concept of *activity orientation* as part of an approach which monitors an actual process. Chapter 3 sets the basis for development, describes the role of the business idea as part of the strategic goal-setting for business and defines the concept *operational success factor*. Chapter 4 examines the means of development and defines the concept of *optimisation* as part of the development of operational business activity.

PART II

Chapter 5 presents existing approaches to problem analysis in development work. Due to the shortcomings observed in the existing approaches, the need for this study is presented.

PART III

Chapter 6 presents the developed model on a general level. Chapter 7 presents actions related to the first stage or stabilisation of the development of the order–delivery process. Chapters 8, 9 and 10 present analysis and development actions as defined by the operational success factor selected.

The analyses developed in this study are reviewed in Chapters 7.4, 7.5, 8.2, 8.3, 9.2, 9.5, 10.2, 10.3 and 10.4.

PART IV

Chapter 11 presents a practical validation of the research result.

PART V

Chapter 12 contains a discussion of the results and proposes topics for further research.

The structure of this research report is presented in Figure 1.2.

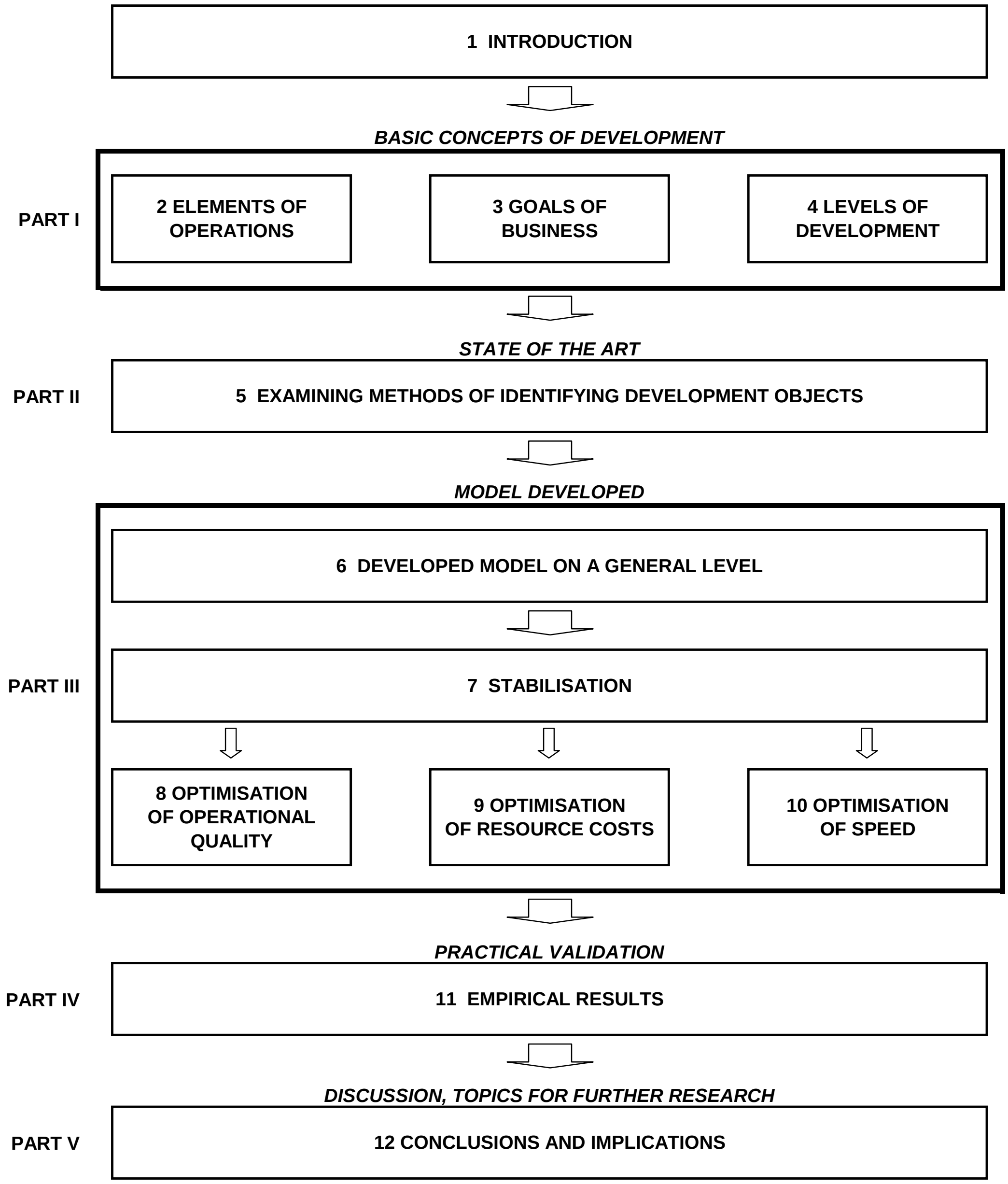


Figure 1.2 Structure of this research report.

PART I:

BASIC CONCEPTS

OF DEVELOMPENT

2 ELEMENTS OF OPERATIONAL BUSINESS

This chapter sets up a frame of reference for an *activity-based* approach. At the beginning of the chapter, concepts related to the modelling of operational business are defined, elements used in modelling are presented and the links between various structures are discussed. These are followed by a more detailed description of how the activity-based model was formed. The chapter concludes with a description of the characteristics of the order–delivery process.

It is easier for us to grasp an issue if we form a model of it. The model may be an unconscious understanding of the matter at hand, present only in our own mind, or it may be purposefully formed and described by means of visual or verbal techniques. A model is an image of the object studied. A model describing a company or other unit may be defined in several ways. A model is mostly constructed for a particular purpose, such as an organisation chart, which describes personal responsibilities and accountabilities. The modelling of information flows is in widespread use in the building of information systems.

In the context of problem-solving and development, modelling is associated with an awareness of problems and development needs and the identification of development objects. Modelling in itself is sufficient to promote development, without express development actions. By creating a shared language, modelling allows people to understand each other better, and they are better able to focus on what is appropriate in their tasks.

Customer needs are satisfied with a product. The product is created through operations. Operations are implemented by consuming resources. Thus, the basic elements of operational business are:

- products,
- operations and
- resources.

On a general level, the operations used to carry on operational business consist of the elements described in Figure 2.1.

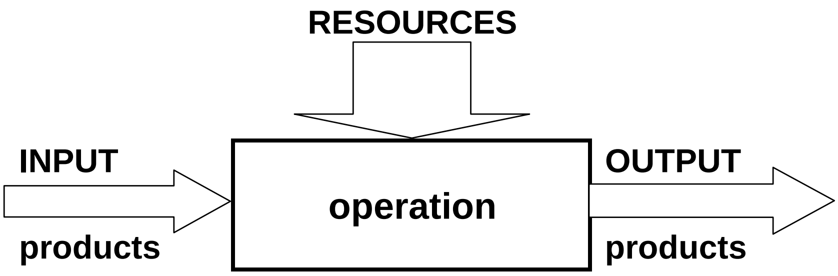


Figure 2.1 Elements of an operation. INPUT products are processed through operations into OUTPUT products by consuming resources.

The following is an examination of these basic elements and other structures crucial to this study: *product architecture, operation structure* and *resource structure*.

2.1 Element 1: Products

The product is the object of operational activity.

The INPUTs and OUTPUTs of an operation are products. The higher-level operation formed by the operations studied is determined on the basis of the links formed by the INPUT and OUTPUT products between the operations studied.

The use of the concepts *production factors, INPUT products* and *resources* in literature is far from unambiguous. As an example, Scott and Sink regard the terms *INPUT* and *resource* as synonymous (Scott & Sink, 1985). According to Hitomi (1990), production factors are:
- production objects, materials,
- productive labour, human ability,
- production means, media and
- production information, production methods.

In this study production factors are divided into INPUT products and resources, which allows a systematic analysis of the following:
- what product (INPUT) is being processed and into what form (OUTPUT),
- what added value is created,
- what resources are consumed in processing and how much,
- what costs are incurred by the consumption of resources and
- what is the processing efficiency.

The concept of INPUT product used in this study corresponds to Hitomi's concept *Production objects*; the object of operations. INPUT products are not consumed in operations, but are processed into a new form, into OUTPUT products.

All OUTPUT products of an operation are not directly offered to an external customer or handled as waste; a support product as an OUTPUT product may, for instance, contain feedback information for an operation which controls and develops the operation studied.

2.1.1 Product sorts

The ISO 9000:2000 quality standard of the International Organization for Standardization defines different product categories: Hardware, software, services and processed materials (ISO 9000:2000).

Juran gives following definitions to the product: "*Product* is the output of any process. It consists mainly of goods, software and services. *Goods* are physical things: pencils, color television sets, office buildings. *Software* has more than one meaning. A major meaning is instruction programs for computers. Another meaning is information generally: reports, plans, instructions, advice commands. *Service* is work performed for someone else. Entire industries are established to provide services in such form as central energy, transportation, communication, entertainment, etc." (Juran, 1988)

In this study, three different product sorts are used to define the product, see figure 2.2.

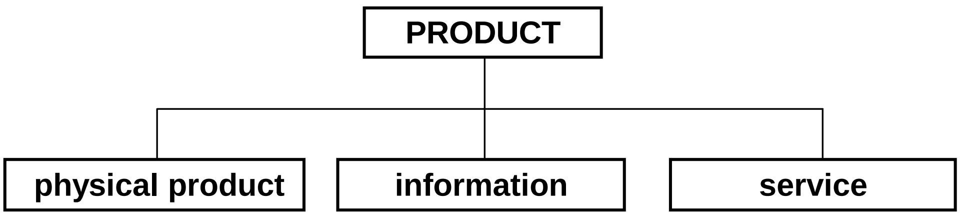


Figure 2.2 Different product sorts defined in this study.

A product is rarely only a physical product; in most cases it is a service combined with physical or information products.

Physical product

The different processing stages of a physical product are represented by:

- *materials*,
- *processed materials*,

- *parts*,
- *components/modules/assemblies* and
- *final products*.

Processed materials are tangible products created by conversion. A processed material may be solid, liquid or gaseous, or a combination of these. Since processed materials represent one stage of a physical product, they will not be discussed separately in this study, but are subsumed under physical products. While energy does not always have a physical state, in this study it is included in physical products.

Information

The different processing stages of an information product are represented by:

- *data*,
- *information* and
- *knowledge*.

Data corresponds to a sign. It may be an alphanumerical figure, a drawing or symbol, or a combination of these. Data does not necessarily have a meaning or a content. By itself, data is not significant or useful. Information is data embedded in a context, a message expressed by a series of signs. Information is potential knowledge. Knowledge is information which has been interpreted, internalised and made relative. New knowledge is accumulated on the basis of existing information. Knowledge may be acquired by internalising and using information.

Service

In this study service is understood as the performance of work. Service is created in interaction between the customer and service provider. The Merriam-Webster dictionary (Merriam-Webster, 2002) gives several definitions for the noun *service*, including: ”The work performed by one that serves, contribution to the welfare of others”, ”Helpful act, useful labor that does not produce a tangible commodity”**.** The purpose of service is often to enable the beneficiary to use or consume a product or resource.

The development of services requires their *commercialisation*. This is based on a definition and description of services in line with customer needs. A service product may be regarded as commercialised when the licence to use or own it may be sold at will.

2.1.2 Product role

The role of the product is determined on the basis of how it is linked to the product offered to the customer:

> *The (final) product which satisfies customer need and the products immediately included in its architecture in different processing stages are **basic products**.*
>
> *The various forms of a **support product**, only used by internal customers, support the basic product in the short and long term.*

A support product may be used to support the basic product in many ways:

- as an indirect part of the basic product not included in the product architecture (such as production additives)
- as an agent of capability, by defining
  - support products / support product architectures (such as control and monitoring data)
  - operations / operation structures and the interfaces between them (such as work instructions, quality manual)
  - resources / resource structures (such as organisation charts)
- by defining
  - operational goals (such as process lead time / time of delivery to customer) and
  - strategic goals (business plan)
- services to maintain resources (such as maintenance of production machinery)
- as a resource created by a support activity to be consumed in other operations (such as *the available floor area*)

2.1.3 Product value

Product value describes the usefulness of the product in the satisfaction of individual or collective needs. The financial value of the product in the marketing area studied is determined by its desirability and, on the other hand, its scarcity.

2.1.3.1 Value of a basic product

Business activity is based on the satisfaction of customer needs with the help of basic products.

> ***The value of a basic product** is defined by the customer who uses the product to satisfy his needs.*

Figure 2.3 shows the components of the value of a basic product.

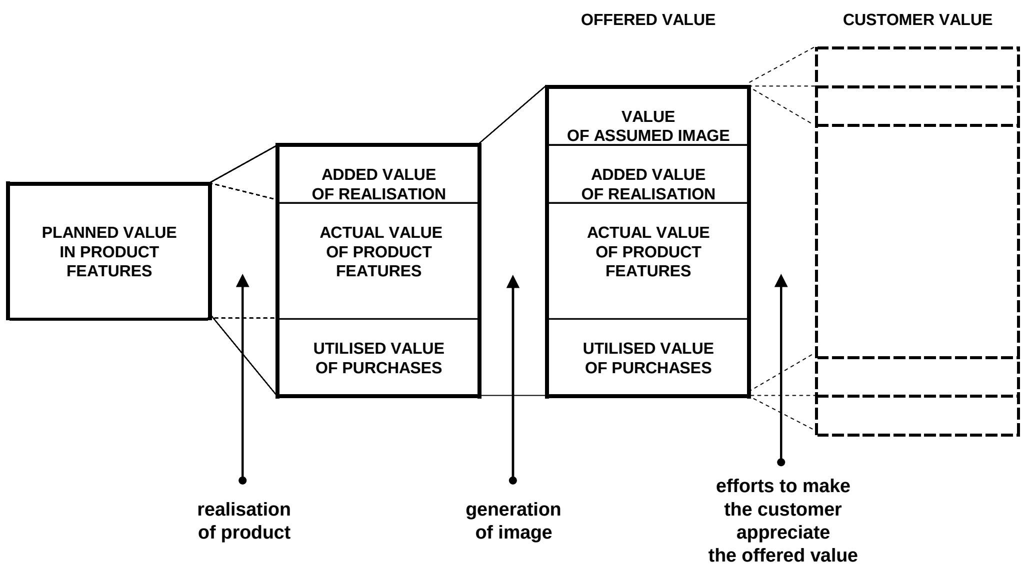


Figure 2.3 Components of the value of a basic product.

In the following text the subchapters discuss the components of the above figure in more detail.

Planned value in product features

The value of a basic product for the customer is largely determined on the basis of comparing product features with the customer's needs. The inherent value of product features is based on the features planned in the product. As a concept, *planned value in product features* contains the values included in the features of all product sorts (physical product, information and service).

To take a simplified example from the automotive industry: Various features can be planned in the product and thus different values can be offered. Two versions based on different engine volumes may be produced of the same make of car. These versions may be completely identical except for the different stroke volumes of the engine. The different cylinder sizes can be achieved by designing different pistons, hinge rods and crankshafts in the same engine blocks. In this case, there is necessarily no difference between the versions regarding the production costs of the engine (and car) or the processing value created during production. The difference in customer values (and customer prices) of the different versions is based on their different product features and eventual differing images.

Actual value of product features

Since the actual features of a product are not necessarily identical with its planned features, the inherent value of the actual features may differ from the planned value of product features. For instance, all planned product features may not always be realised when a service is realised. The ability of the object studied to realise the planned product features may depend on such factors as the degree of correspondence between the product, the operating mode and the resources to be consumed.

Utilised value of purchases

The share of purchases of the value offered to customer frequently does not correspond to the financial value of purchases. When the product is realised, part of the value of purchases may remain unutilised, or the value of purchases may be utilised several times over (such as with an information product which may be multiplied). Thus, the definition of the value of purchases in this context, as part of the value offered, is based on the concept *utilised value of purchases*.

Added value of realisation

According to the Finnish Committee for Corporate Analysis, *added value of realisation* is used to measure the added value generated by a company in the products or services (Committee for Corporate Analysis, 1999, p. 68). In this study, added value of realisation is limited to include the share of added value which is generated in the context of product realisation, the phase when the product and its features are made concrete. Thus, the added value of realisation describes the value added to a material or intermediate product, for instance, as it passes through the production operations.

The added value of realisation also includes the added value derived from certain competitive factors (such as homogeneous quality or short, controlled delivery times) created during the realisation of the product and offered to the customer. It should be noted that this component of the added value of realisation does not come about exclusively during product realisation. The homogeneity of quality and short, controlled lead times of the order–delivery process are affected by the product and the corresponding product architecture.

Offered value

The final value of the product is determined by the customer. The *offered value* corresponds to the company's conception of the customer's needs and expectations. The value which the company offers on the market in the form of the product is the sum of the utilised value of the purchases made by the company and the value realised by the company. The value realised by the company consists of the features of the product to be offered to the customer, the added value of realisation and the company image:

	utilised value of purchases
+	*actual value of product features*
+	*added value of realisation*
+	*value of assumed image*
=	*Offered value* (1)

In practice, product value is more difficult to determine because of the traditional cost-based pricing practices of Finnish companies, based on profit margin.

Value of assumed image

Porter calls the factors which influence the forming of image *signals of value* (Porter, 1985). In assessing the value offered by the company, the customer is assisted by such things as advertising, reputation, packaging, professional skill, appearance and personality of employees, amenity of production facilities and the information provided by the company as sales promotion. At the customer interface, the image is maintained and developed, distribution is assured and efforts are made to make the customer recognise and appreciate as much of the value offered as possible.

Customer value

According to Porter (Porter, 1985), the company should use its products to improve the customer's performance. The company's ability to do so depends on whether it understands what performance the customer hopes for. Frequently, customers do not exactly know all the ways in which a supplier can or could lower their costs or improve their performance; in other words, customers do not know what they ought to require of the supplier. Value is the quantity which customers are prepared to pay for the product. Customer will not pay for unappreciated value. The eventual extra price for the company thus depends both on the value offered to the customer and on the degree to which the customer appreciates this value.

Dumond (2000) has summarised the definitions of value:

- customer value is associated with product use; to that extent it is therefore different from personal values,
- customer value is appreciated by the customers rather than objectively determined by the seller and

- customer value is typically linked with the relationship of what the customer gets and what he gives in order to get the product and to use it.

In this study, customer value is understood according to Porter's definition of value (Porter, 1985, p. 38):

> *"Value is the amount buyers are willing to pay for what a company provides them."*

In this case:

Customer value $\geq$ customer price.

At the customer interface, companies attempt to maximise *customer value* by helping the customer recognise and appreciate as much of the *value offered* as possible.

The customer may apply a particular *value analysis* for defining customer value. In the 1940s, General Electric Co. developed the *value analysis* to examine the interaction between the usefulness of raw materials and purchased components and the cost of using them (Gage, 1967). Value analysis regards some of the product features as absolute, others as desirable and the rest as unnecessary. Only absolute and desirable features add value, and they are the only ones which people are willing to pay for. Value analysis can also be applied to other than physical products.

2.1.3.2 Value of a support product

The value of a support product is not determined directly by its internal customer alone, since support products are often used to determine the entity formed by individual operations and the share of each operation in that entity. In this study, the value of a support product is defined as follows:

> ***The value of a support product*** *is based in the short run on its usefulness for the realisation of basic products and, in the long run, on its usefulness in attaining strategic goals.*

2.1.4 Product architecture

Product architecture both describes and determines the products which the product studied (the end product offered to customer) consists of. In this study, all product sorts are included in the product architecture as of equal value. Thanks to the product architecture, different *views* may be gained of the product, in which the products included in the product architecture are grouped case by case to assist understanding and manageability. The structure formed by the parts list enclosed to the drawings made of a physical product by the product design unit is often called the design structure. In production and materials planning, the Bill of Materials (BOM) of a physical product defines the materials, parts, components and assemblies included in the final product.

An end product based on standardised modules and varied according to customer need is an example of modular product architecture. According to Lapinleimu, a modular product architecture may be considered ideal (Lapinleimu, 2000). It makes sense if the modular product architecture is accompanied by a corresponding operation structure. In order-driven production it is often appropriate to identify the stage of product architecture at which the product versions are differentiated, and a modular product architecture enables a clear and manageable interface for product differentiation.

There exist obvious reservations with regard to treating the range of products as homogeneous. Understanding the differences between divergent customer needs and the differences in the corresponding products and product architectures may provide significant help in developing and focusing the business activity.

2.1.5 Product adaptability

Awareness of product adaptability forms one of the starting-points for controlling the order–delivery process, to be discussed later. An operating mode geared to standard products will naturally be different from one clearly geared to customised products. From the point of view of successful activity it is essential to recognise the type of customer needs which the company's products attempt to satisfy, and to implement the requisite measures. Companies need not try to satisfy every whim of their customers. The goal of a company functioning on the basis of business economy is to make a profit. This crucial message was put somewhat differently by Arno Saraste:

> *”Let us make our customer happy on our terms,*
> *rather than making ourselves unhappy*
> *on the customer's terms.”*

Product adaptability may be described using different product architectures. Product architecture may vary depending on product adaptability in the following ways, for instance:

A products: **Standard products** correspond to product specifications defined in advance, completely standardised, possibly capable of being stored if physical products.

B products: **Varied products** are varied from modules based on standard interfaces according to order or case. By means of a standard service component included in the product, a product may be created to fit a given case.

C products: **Customised products** are designed case by case. They can be new products or customised old ones. The product includes a case-specific degree of customising (design/planning) service.

As the case-specific customising for a product increases, the share of case-specific service increases, as presented in Figure 2.4.

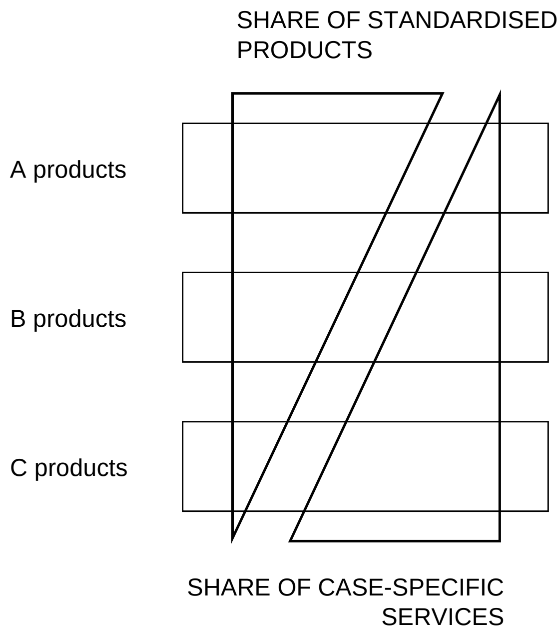


Figure 2.4 Different product architectures of products with different adaptability.

Product architectures with different adaptabilities require different operating modes and may thus form distinct business areas with distinct business ideas.

2.1.6 Product maturity

The degree to which a product has been *commercialised* may be described by product *maturity*. Sipilä has described the degrees of service commercialisation, for example (adapted from Sipilä, 1995):

- internal working methods and operating modes of the service have been systematised,
- a service support is used to augment the service,

- the structures, operations, methods and tools of the service have been commercialised as far as possible, and
- the service can be multiplied and delivered to a distribution channel, the service exists in a physical or electronic form.

2.2 Element 2: Operations

Hitomi (1990, p. 275) is one of the authors who have presented the definition of “Production” as “the process of producing economic goods, including tangible products and intangible services, from factors of production, thus creating utility by increasing value added”; this can be viewed as an “input-output system”. The system receives inputs from its surroundings, converts them into outputs and releases the outputs into its surroundings, attempting to maximise the profitability of the conversion. The system is a procedure – a series of logical, chronological steps, on the basis of which all recurring tasks are completed.

In this study the generation of products is described by means of *operations* of varying sizes; INPUT products are converted into OUTPUT products through operations. According to need, an operation may be defined as extensive or small in scope. Chapter 2.2.3 presents some general labels given to operations of different sizes.

2.2.1 Operation role

The role of an operation is determined by the role of the OUTPUT products achieved by it. Operations may be categorised in several ways (Brimson, 1991; Department of Defense, 2001; Pastinen, 1998). The following definitions are applied in this study:

> ***A basic operation*** *generates basic products or basic and support products. Without basic operations business activity will cease or suffer immediate difficulties or delays.*
>
> ***A support operation*** *only generates support products. Without support operations business activity will cease or suffer difficulties or delays in the longer run.*

Activity-Based Costing (ABC) also applies the corresponding concepts; the cost of support operations is traced to basic operations, and the cost of basic operations to selected cost objects (products) by means of cost drivers.

Basic operations may be linked to the basic products in different ways. They may

- define the product,
- develop the product,

- realise the product, or
- offer the product.

A support operation supports other operations by releasing purchased materials, human resources and various services which extend across the value net. The OUTPUT products from support operations may be consumed in other operations as resources, or they may maintain resources. As an example, most operations use as resources the OUTPUT product *Available floor area* of the activity *Building management*. Similarly, the activity *Personnel administration* supports and maintains the resource *Personnel*.

2.2.2 Effectiveness of an operation

The effectiveness of an operation is based on its capability of increasing product value. Even at the modelling stage it is appropriate to pay attention to the effectiveness of operations. Value adding operations have not been defined unambiguously in literature. In certain sources (e.g., Adams Six Sigma, 2001), value-added operations are considered to be operations which create an added value that exceeds the cost of resource consumption. In this study, value added and the corresponding cost are dealt with separately and are defined as follows:

> ***A value-added operation*** *increases the value of the product.*
>
> ***A non-value-added operation*** *does not increase the value of the product.*

In addition to non-value-added operations it is possible to distinguish so-called value-destroying operations:

> ***A value destroying operation*** *decreases the value of the product.*

In determining the effectiveness of an operation no attention is paid to the efficiency of the value-added operation or the degree to which the INPUT products acquired for the operation are utilised.

2.2.3 Operation structure

In this study, operation structure describes the entity formed by the operations necessary for the generation of the products studied, and by the links between these.

A widespread approach to business in companies is the value chain presented by Porter; every company consists of a number of activities to design, manufacture, market, deliver and support the product. All these activities may be described by the value chain, Figure 2.5.

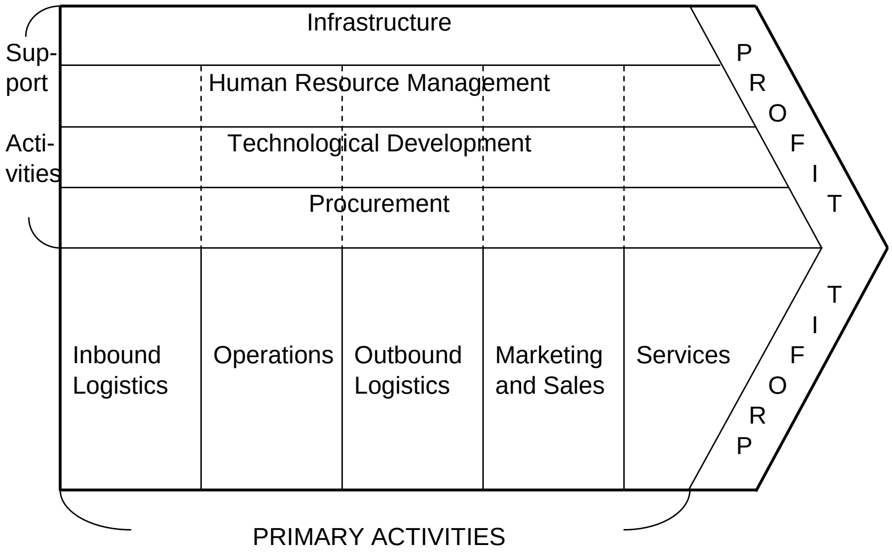


Figure 2.5 Value chain in a company according to Porter (1985).

According to Porter, the company's value chain and the manner in which it realises individual activities will reveal its history, strategy, strategy implementation, and the financial laws governing the activities themselves. Using the value chain, a company may be systematically divided into separate activities; thus, the value chain may be used to examine the current or ideal groupings of a company's activities. In his book *Competitive Advantage*, Porter presents the concept *value system* (Porter, 1985, p. 34): ”A company's value chain is embedded in a larger stream of activities that I term the *value system*.”

In this study, the most extensive operation examined is the *value net*. A value net is formed by interconnected operations. Figure 2.6 presents the hierarchy between operations of varying sizes in the value net.

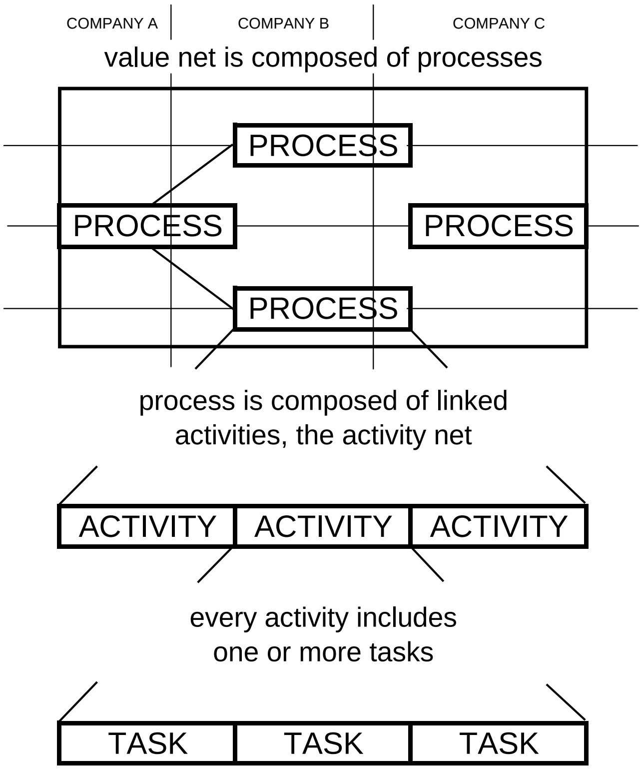


Figure 2.6 Hierarchy of a value net.

In a model of the operation structure, operations are grouped in the way most appropriate for understanding and manageability; to be understandable, the model needs to be as simple as possible, but nevertheless detailed enough to make the net manageable (to allow the identification of cause and effect). To improve understanding and manageability, small operations are grouped into larger ones (tasks into activities, activities into processes) and/or large entities are split into parts (processes into activities, activities into tasks), etc.

As emphasized in this study, the operation structure should rely on the same starting-points as the architecture of the product studied. The current state of the operation structure is described by the AS-IS model, its future state by the TO-BE model.

Value net

The value net is based on the product offered to the customer. The actors included in a value net operate in partnership; among other things this means that the performance of the value net is improved and optimised as one entity. With the increasing networking of companies, the examination of value nets becomes increasingly important. Instead of companies competing against other companies, it is the value nets which compete against each other.

Process

During the 1990s, the concepts of *business process* and *activity* were widely used in describing company operations. A process consists of one activity or of a net formed by several activities, as is shown in Figure 2.6.

Authors such as Hannus (1994) have presented the process-based approach and process management in the following terms: "In process management, the starting-point is to abandon the fetters of functional management and organising, and to examine the company activity as one entity which produces value for the customer." The approach adopted in this study assumes that the limits of business processes do not necessarily conform to company limits. One definition of a core process is by Prosci (2001): "Business processes are simply a set of activities that transform a set of inputs into a set of outputs (goods or services) for another person or process using people and tools."

In general, processes directly linked to an external customer are called *core processes*. Processes whose smooth operation is vital for the company success are called *key processes*.

Activity

The functional sections of a company organisation has generally been understood in Finland as *functions*. The functional organisation is an attempt to improve the potential for a better operational management, by centralising the realisation of operations in defined resource units, or departments. For instance, the realisation of the activity *marketing* may be centralised in the resources available in the marketing department. In this study, however, the concept *activity* is used to describe an operation of a certain size. A concrete difference between these approaches is that in practice, the activity *marketing* is realised by many other resources besides those available to the marketing department.

Activity-basedness as a concept became more widespread in the early 1990s, when the tracing of general business costs was increasingly improved by using the Activity-Based Costing method developed by Cooper and Kaplan at the Harvard Business School (Cooper & Kaplan, 1988).

The order–delivery process, which is selected for development within this study, will be modelled through activities, since they are the most appropriate level for development, being neither too rough nor too detailed for examining the order–delivery process.

Task

Activities consist of tasks. Tasks and work stages describe action on a detailed level.

Work measurement, which is part of traditional time-and-motion study, uses even more detailed divisions. In work measurement work is divided into suitable sections for measurement. This allows the creation of an *element breakdown system*, in which work sections of different sizes are located on different levels, with the smallest ones on Level 1. The smallest work sections, *motion sequences* and *basic motions* may take less than two seconds to achieve.

To draw the boundaries between different operations, it is assumed in this study that in a medium-sized value net, the following numbers of various operations may be identified:

operation	*number*
key process	a few (3–6)
activity	a few dozen (30–50)
task	several dozen (50–100)

2.2.4 Operation adaptability

The realisation of products with different adaptabilities requires operations of different adaptability. In manufacturing products with different architectures, such as in Figure 2.4, corresponding different operation structures are also needed. The order–delivery processes corresponding to different products each have their own activity nets, lead times and cost structures. The order–delivery process of standardised "A" products may be completely standard and based on routines. The order–delivery process of "B" products, with order-specific variation, may also be standardised and based on routines. The management of the order–delivery process of "C" products, customised for each order or case, resembles project management based on permanent instructions. The most essential difference between the degrees of adaptability required by different order–delivery processes lies in the degree of decision-making required by a single order. Figure 2.7 presents a simplified example of possible operation structures of the alternative order–delivery processes in a company.

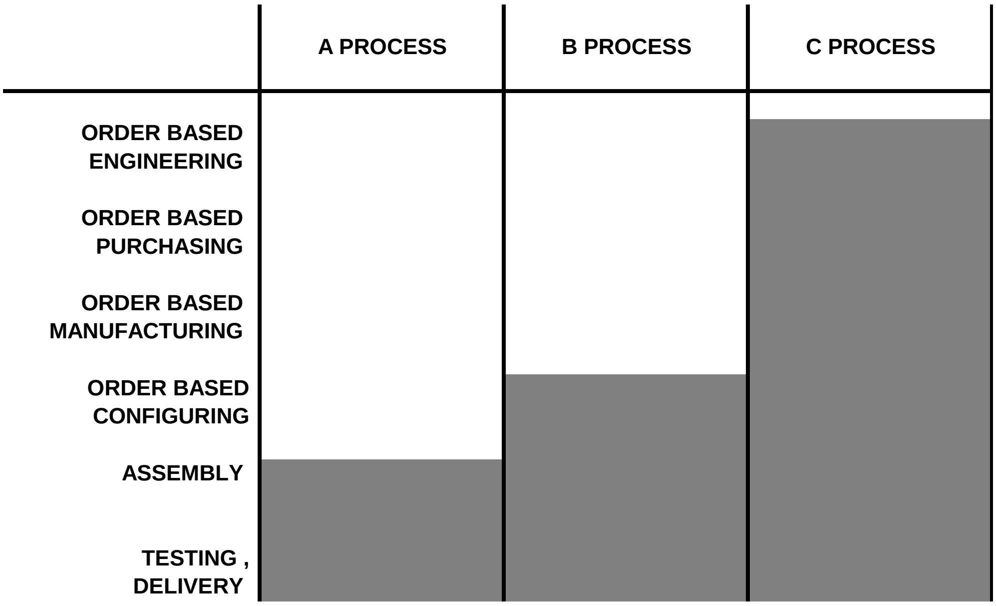


Figure 2.7 Alternative order–delivery processes based on different product adapta-bilities.

The added value created in the order–delivery process of "C" products is generated as part of the decision-making and implementation as a result of the realisation of order-specific services.

2.2.5 Operation maturity

Several models have been presented for the recommended progress of process development. The starting-point for development is considered to be the definition of the current level, and the goal is to achieve a higher level.

Harrington (Department of Defence, 2001), presents a system of process assessment and qualification with designations ranging from *unknown status* to *world-class*. Each higher levels includes the qualifications of all lower levels:

level	status	description
6	Unknown	Process status has not been determined
5	Understood	Process design is understood and operates according to pre-scribed documentation
4	Effective	Process is systematically measured, streamlining has started and end-customer expectations are met
3	Efficient	Process is streamlined and is more efficient
2	Error-free	Process is highly effective (error-free) and efficient
1	World-class	Process is world-class and continues to improve

The ISO 9004 standard presents the performance maturity levels used in the self-assessment of an organisation's quality management system (ISO 9004:2000). The performance maturity levels according to ISO 9004 standard are shown in Table 2.1.

Table 2.1 Performance maturity levels according to standard ISO 9004.

Maturity level	**Performance level**	**Guidance**
1	No formal approach	No systematic approach evident; no results, poor results or unpredictable results.
2	Reactive approach	Problem- or prevention-based systematic approach; minimum data on improvement results available.
3	Stable formal system approach	Systematic process-based approach, early stage of systematic improvements; data available on conformance to objectives and existence of improvement trends.
4	Continual improvement emphasized	Improvement process in use; good results and sustained improvement trends.
5	Best-in-class performance	Strongly integrated improvement process; best-in-class benchmarked results demonstrated.

The Software Engineering Institute (SEI) at the Carnegie Mellon University has developed the Capability Maturity Model (CMM) to evaluate the maturity of the software development process. In Version v1.1 of the CMM there are 5 distinctly defined maturity levels (Sern 2001). They are:

1 *Initial* - This level is essentially ad hoc or possibly even chaotic. There are no formalized procedures and plans. The majority of people's work is fire fighting.

2 *Repeatable* - A stable process is in place with statistical controls. Project management principles are used for commitments, costs, schedules and changes.

3 *Defined* - The stable process achieved at level 2 has been defined as the organizations Software Process and is used consistently as the basis for implementation.

4 *Managed* - Comprehensive measurements and analysis processes are occurring. These can now be used as the basis for continued improvement.

5 *Optimizing* - Continued improvement and optimization occurs based on sound principles coming from the application of findings based on the scientific collection of measurements and data

In theory the CMM model could be completed with a sixth level:

6 *Reengineerable* - The process has the capability of examining critically its own activity and to call its existence into question. The process has the capability of renewal.

The highest maturity level of a process – *Reengineerable* – should not be confused with reengineering initiated by an external actor. The *Reengineerable* level denotes a state in which the process itself identifies its capabilities and limitations well enough to be able to renew itself autonomously when needed.

2.3 Element 3: Resources

Resources are consumed in order to realise operations. Resources carry out work, process INPUT products into OUTPUT products, or they are used to carry out work. Costs are incurred by the consumption of resources.

2.3.1 Resource sorts

Cost-incurring resources may be divided into resource sorts as in Figure 2.8: personnel, energy and tied-up capital in its various forms. Moreover, the support products offered by the support operations in the same operation structure form a resource sort of their own. A resource sort may be consumed in both basic and support operations.

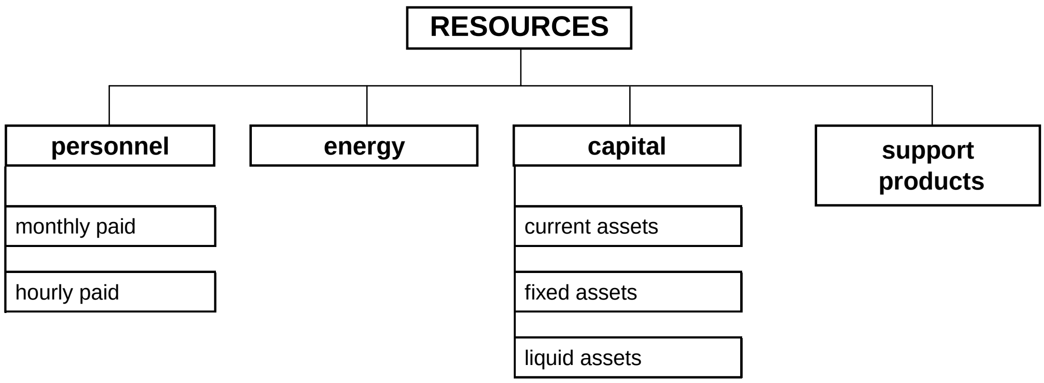


Figure 2.8 Resource sorts.

As an example, the support activity *Building management* generates the support product *Available floor area* to be consumed as resource by other operations.

The resource sort *Personnel* could be subdivided in many different ways. When materials, purchased components and intermediate products are processed in operations, they are treated as INPUT products. When materials, purchased components or intermediate products are waiting or queuing for an operation, the capital tied to them, current assets, is treated as a resource.

2.3.1.1 Resource role

The role of the resource is determined on the basis of how it is linked to the realisation of the product.

> *The work done by **basic resources** adds value to the product immediately. Consumed amount of basic resource depends on the amount of realised products.*
>
> ***Support resource** participates indirectly to the realisation of products. Consumed amount of support resource depends on the (calendar) time.*

2.3.2 Resource structure

Resource structure describes what organised resources are consumed in the operations studied and how this is done. In this study, the examination includes the appropriate parts of the organisation of resources consumed in the order–delivery process; the personnel organisation, the layout of the production equipment, etc.

In the context of modelling, resource sorts must, when needed, be arranged into groups which behave in a homogeneous manner from the point of view of examination. Individual resources with significant cost and capacity impacts should be treated independently.

Lapinleimu (Lapinleimu, 2001) defines the manufacturing unit and its multilevel structure as follows: "The basic element of the production system is the basic manufacturing unit. The unit consists of both technology and the personnel using it. Basic units can be combined to larger wholes, usually into factories. In this case, the basic units carry out component manufacturing or assembly, and they act as nodes in the manufacturing flow. Basic units and the factories consisting of them are both called by the term manufacturing unit."

The resource structure should rely on the same starting-points as the operation structure. If the value net produces one-off customised products, its mode of operation and organisation must follow to this. In this context it is appropriate to distinguish between stable resource structures and one-off project groups and teams.

2.3.3 Resource adaptability

The examination of resource adaptability is essentially linked to the time span applied. Resource adaptability at a given point in time is related to the goal-setting at the same time, with the product range currently being produced. The capability of resources to correspond to different goals valid at different points in time is described by resource adaptability.

2.4 Connections between structures

The basic starting-points of business are greatly affected by the degree of correspondence between the product architecture, operation structure and resource structure. In an ideal case, the operation structure corresponds to the product architecture and the resource structure to the operation structure. Figure 2.9 presents the connections between different structures as they are understood in this study.

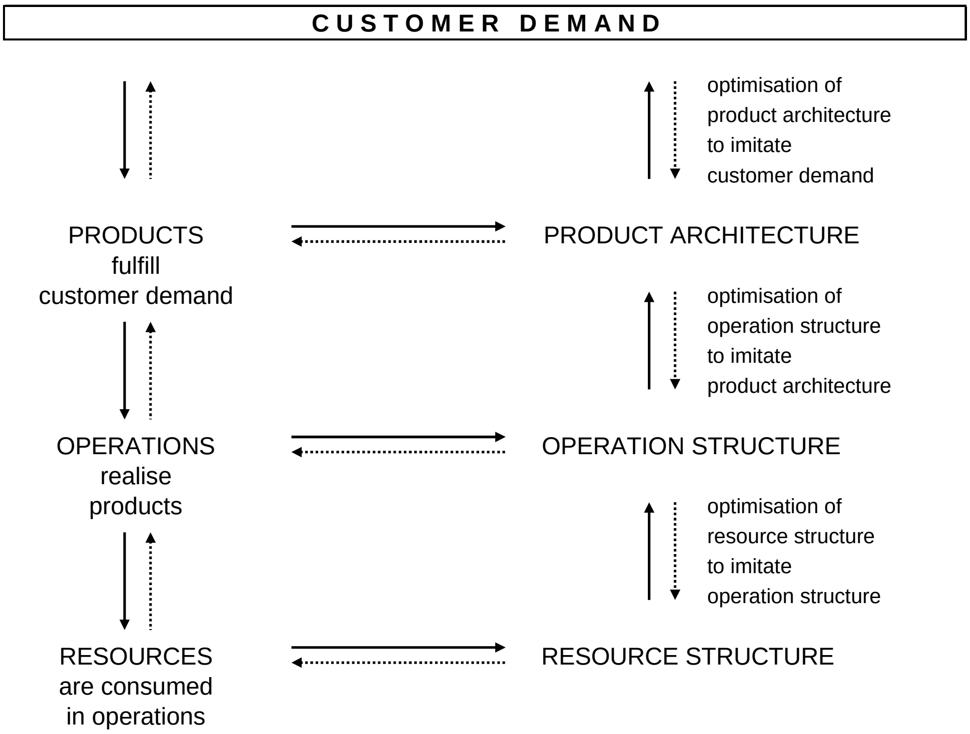


Figure 2.9 Connections between structures.

Products are not always defined on the basis of existing customer needs. New technologies enable the creation of new customer needs and new products. Akio Morita, the CEO of Sony, is reported to have said (Willis, 1999):"*Our plan is to lead the public with new products rather than ask them what kind of products they want.*"

Similarly, operations are not always defined from products. If the operation and resource structures are difficult to adapt, it may be appropriate to improve product *producibility* by adapting the product and product architecture to existing operations and operation structures.

Following are some examples of connections between structures:

The standardisation of the basic product architecture by means of *platforms* enables more stable product architectures and operation and resource structures. This is exemplified by large automotive companies which are capable of extreme flexibility in manufacturing different versions of the same base plates, using operations and resources determined by the base plate.

In the feature-based, computer-aided design of physical products, the standardised methods and operations needed to realise features may be defined in the basic data for each feature. Thus, the production methods of a product modelled on the basis of features will be determined together with the product modelling.

Connections between operation elements are also taken into account in such procedures as data modelling. Also called entity–relationship modelling, this is a modelling culture linked to software design. The phenomenon to be elaborated is described as entities and the relations between these. With the help of an entity relationship diagram it is possible to write a description of the database for the application, producing an empty database which will then be filled with data and processed with software. The objects to be described may be both products, operations and resources. lsms of business modelling based on data modelling exist (Savolainen et al., 1997), which first describe the entities dealt with in the business processes, such as materials, intermediate products, information, etc. After this the business processes are described, which enables the streamlining or inventing of ways to generate the entities described. In other words, the product architecture is described first and then used to create the operation structure.

Finnish metal industry in the 1980s strongly favoured manufacturing cells. In an ideal product-based manufacturing cell the product architecture and operation and resource structures correspond to each other.

In practice, many Finnish mechanical workshops maintain so-called *production structures* on the product, in which the *planning structure* created by the planning department for the product has been modified to suit the existing operation structure. In future, IT is increasingly used to simplify the situation: the shared product architecture may be examined through different views created to suit the needs of different user groups.

The personnel resources of Toyota have been organised to respond to current problems on a case-specific basis. Depending on what is needed by the personnel, expertise and support are organised in different ways according to situation (Spear and Bowen, 1999).

Since organisation charts are traditionally arranged according to functions and in a vertical direction, a horizontal model describing an operation chain in line with the actual process is often called *cross-organisational*. If personnel resources are organised in the traditional, function-based manner, the resource structure in question rarely corresponds to the operation structure. For instance, the activity *Bid calculation*, which precedes the order–delivery process, may utilise resources from the product development, production, purchasing and marketing departments.

The division into profit centres, traditionally used in internal cost calculation, is based on the function-based organisation chart and the corresponding hierarchical accountabilities. Cost calculation which relies on this type of resource structure is capable of answering the question, "Where have costs been incurred?" In Activity-Based Costing based on the operation structure, the main focus lies on doing. In this case the cost calculation is capable of answering the question, "Why have costs been incurred?" In Activity-Based Costing, the impact of product and product architecture on the resource amounts consumed and on costs are described by so-called *cost drivers*. Although Activity-Based Costing does not use the concepts of operation and resource structure, ABC may be said to use so-called case-specific *cost driver structures* to determine the cost effect of different product variations, based on the current operation and resource structures.

2.5 Activity-based modelling

Since this study focuses on the development of the existing mode of operation, the modelling mainly focuses on an activity-based AS-IS model of the order–delivery process. The main weight of the description lies on the connections between operations which are created by product flows.

2.5.1 Process map

The connections between the processes in a value net are examined with the help of a *process map*. Before drawing up a process map, the value net is described as is shown in Figure 2.1: Which INPUT products derived from outside the value net are processed by the value net as its own OUTPUT products? Figure 2.10 presents a simplified example of the INPUT and OUTPUT products of a value net.

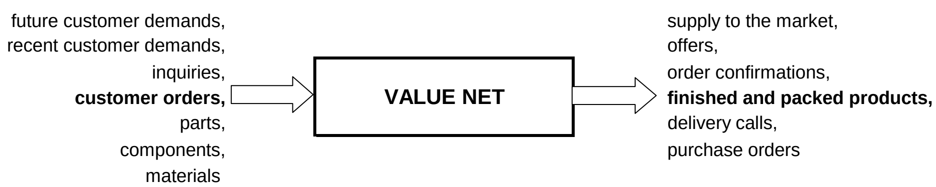


Figure 2.10 INPUT and OUTPUT products of a value net.

The process map describes the organisation units of the companies and stakeholder groups which form the value net, on the basis of the resource structures, as well as the business processes across these. The process map is complemented by a manual which determines the INPUT and OUTPUT products of each process. Figure 2.11 presents a sample process map of a value net.

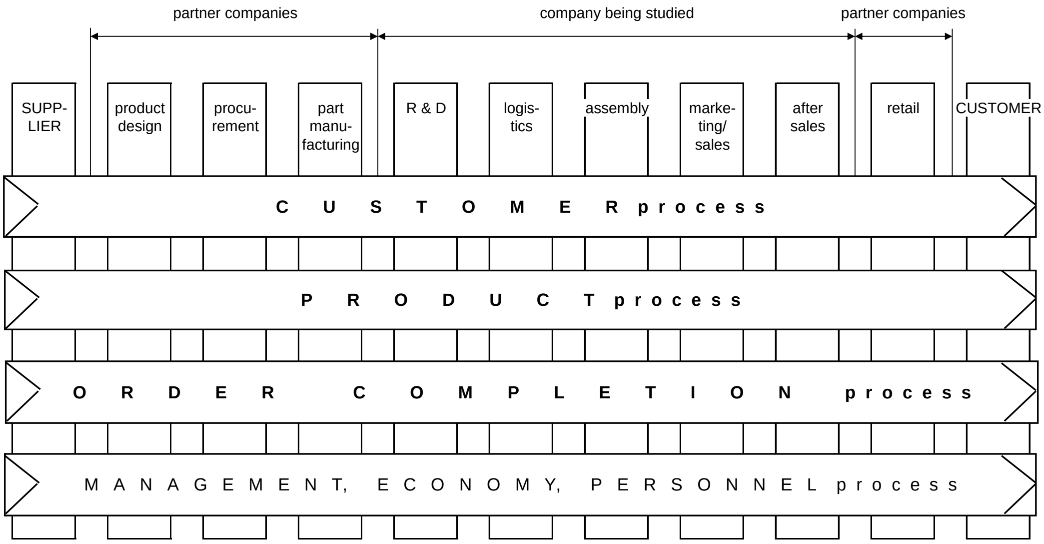


Figure 2.11 Process map of the key processes of a value net.

Figure 2.12 is a simplified presentation of the INPUT and OUTPUT products of the key processes in the same value net.

INPUTs	CORE PROCESS	OUTPUTs
future customer demands, recent customer demands	**CUSTOMER**	defined business idea, supply to the market
defined business idea	**PRODUCT**	product definitions
inquiries, customer orders, product definitions, parts, components, materials	**ORDER COMPLETION**	offers, order confirmations, delivery calls, purchase orders, finished and packed products

Figure 2.12 The INPUT and OUTPUT products of the key processes in the above value net.

2.5.2 Formulating the activity-based model

In an activity-based model, the process studied is described by means of groups formed of interconnected tasks, that is, of activities.

Business activity has traditionally been modelled for various purposes:

- action plans
- quality manual
- definitions for Management by Objectives
- job descriptions
- IT system definitions, information flow charts
- procedures, work instructions
- work flow charts

The general drawback of these descriptions is that they only include value-added operations. Action (use of time) has not been described in its totality, so that only operations considered necessary for the business goals have been included. It may be difficult to discern key processes and corresponding activity chains in a quality manual written on the basis of the previous quality system standard. Descriptions of existing action descriptions may, however, help to ensure that nothing essential is omitted from the model to be formulated.

Definition of activities

Modelling depends very much on the case at hand. A rapid, although less accurate, way is to form an image of the process operation by interviewing the key persons for each process. A questionnaire prepared in advance is always a useful support for the interviews. The interviewees may be either persons who carry out the process or their supervisors. It is wise to bear in mind that the supervisors do not always know how the process actually works.

Most frequently, the most appropriate way is to construct the model as teamwork by persons who carry out the process, making use of such methods as the *wall-chart technique* (Savolainen et al., 1997). As prescribed by this technique, all problems and suggested improvements should be recorded during the discussion. The practical modelling is facilitated by prepared forms for recording the elements of the activities studied. When the forms are posted up on the wall, a clear picture of the model is immediately available.

The success of modelling is evaluated by the usability of the description arrived at. Is the level of examination appropriate for the model's clarity? The description often becomes unnecessarily detailed and accurate. Frequently, it is appropriate to elaborate on the initial description, perhaps by grouping tasks in to activities. Some examples of tasks included in the order–delivery process are:

INPUT	TASK	OUTPUT
work order, production plan	ASSIGNING OF JOB NUMBER	job number, advance hours
job number, advance hours	ADVANCE LOAD	advance load by load group
advance load by load group, production plan	SCHEDULING	production schedule

Together, these tasks may form an activity:

INPUT	ACTIVITY	OUTPUT
work order, production plan	ADVANCE LOAD	production schedule

Scope of activities

Activities serve internal or external customers through their products. Each activity is responsible for making the product available to the customer at an agreed time and place. Thus, the activity includes the *moving and storaging tasks* of the product, with the associated capital and other costs. If *moving* and *intermediate storaging* are found to be independent activities, it is possible to examine their usefulness with the help of analyses presented below.

Description of the model

This study emphasises the description of connections between operations. These connections are formed by the product flows of INPUT and OUTPUT products between operations. The simplest way of describing these is to use the kind of diagonal matrix presented in Figure 2.13.

In the diagonal matrix, the activity chain of the *order–delivery process* is described on the diagonal. The beginning includes the suppliers, representing operations outside the process, and the end includes the customers. The INPUT products of an activity along the diagonal are located in the appropriate column and the OUTPUT products on the appropriate line.

SUPPLIERS			product definitions				parts, components, materials	
	OFFER PROCESSING	sales structures						offers
		ORDER PROCESSING		order structures			packing lists, freight lists	order confirmations
	bills of materials, item definitions		ENGINEERING	drawings				
delivery calls				WORK PLANNING	purchase proposals	plans, schedules, instructions		
purchase orders					PURCHASING			
						PRODUCTION	finished products	
						parts, components, materials	RECEIVING AND SHIPPING	finished and packed products
	inquiries	customer orders						**CUSTOMERS**

Figure 2.13 Activity-based model described as a diagonal matrix.

A diagonal matrix is a flexible tool for constructing a process description. The matrix is easy to enlarge and update with additional information. The diagonal matrix reveals the connections between operations, but the progress of time is difficult to appreciate. A description of the order–delivery process as an activity net helps to understand the order of events between activities. This description may be constructed by combining basic elements of operations as presented in Figure 2.1, while omitting resources. The description presented in Figure 2.14 may be considered as clearer than a diagonal matrix, but without appropriate software tools this type of presentation is difficult to make and update.

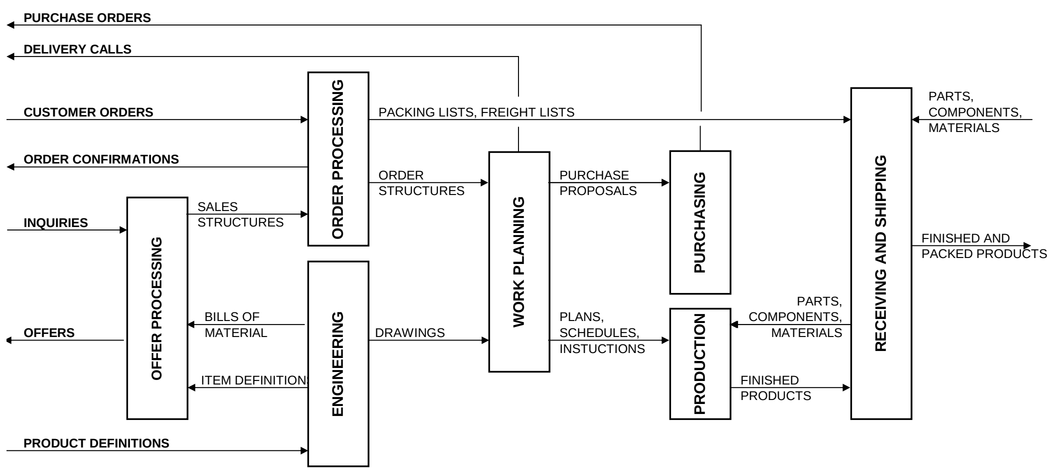


Figure 2.14 Activity-based operating model described as an activity net.

The description presented in Figure 2.14 is closely linked to the IDEF0 (Integration DEFinition language zero) description standardised in the USA. In IDEF0, the control and monitoring impulses have been separated from the general flow of information, and the description also includes resources and links with other processes (Savolainen et al., 1997).

2.6 Typical features of the order–delivery process

This section presents examples of elements which are typical for the order–delivery process of physical goods.

Physical products

As its INPUT products, the order–delivery process may process all the different processing stages of a physical product.

Information products

The order–delivery process uses at least the following information products as its INPUT products:

- information products as support products:
  - connections and interfaces of the operation of the value net
  - goal-setting of operational performance
- information products as basic products:
  - immediate operational control information: What, When, How much, To whom?

Services

Production companies may be divided into main suppliers and subcontractors. The business of main suppliers includes their own end products, to achieve which they purchase processing services from subcontractors. When focusing on their own core areas, main suppliers typically outsource activities outside their core competence. Outsourcing expands the product palette of subcontractors, especially those willing to be system suppliers, by the following types of service products:

technical advice	product planning
manufacturing planning	pricing
purchasing	warehousing
assembly	quality control
packaging	transport
installation	forwarding
invoicing	

The fact that traditionally no services except manufacturing services were regarded as products can be seen in pricing, for instance: the cost of new service products is generally subsumed in the prices of physical products. It would be more clear-cut to commercialise these services and price them separately, using *Activity-Based Costing*, for example.

INPUT products in the order–delivery process

Table 2.2 presents different sorts of INPUT products in the order–delivery process, grouped according to the product role as defined in chapters 2.1.1 and 2.1.2.

Table 2.2 Typical INPUT products of the order–delivery process.

	physical product	**information product**	**service**
supporting INPUT products	additives not included in product specifications, fixing supplies	definitions of the operation's connections, the operation's goal-setting, basic product information which defines repeated OUTPUT products	purchased services related to resource maintenance: cleaning, maintenance, etc.
basic INPUT products	materials, parts, components, modules, assemblies	product specification per customer order, delivery time, terms of delivery	order-specific planning, consulting, realisation and inspection services

3 GOALS OF BUSINESS

This chapter examines the determining of strategic goals, which form the guideline for developing operational capabilities. At the beginning, strategic planning is discussed to the extent necessary for setting the goals appropriate for the order–delivery process. Strategic planning and business idea are discussed from the viewpoint of a single company, since strategic planning for a whole value net remains rudimentary so far. Certain important concepts used in this research report are also defined here. The chapter concludes with examples of key figures which can be used to concretise and measure the goals set for the order–delivery process.

3.1 Strategic planning

Strategic planning deals with the determining of a shared vision. At best, strategy serves the company personnel and decision-makers in day-to-day choices and decisions. Selecting an option which falls in line with company strategy should be easy, and it should support choices made by other people with the same purpose (Sjöholm, 2001).

In a consultancy handbook published by the European Union (The European Handbook of Management Consultancy 1995, p. 18), strategy is defined as follows: "A strategy is a general plan for the way the company will deploy its competence and resources in order to achieve its overall goals." Strategy defines the way in which a company develops its capabilities and resources in order to meet market demands so as to earn money.

Strategic plans describe the rules of game, events and decisions which lead from the current state to the future desired state. Strategic decisions are choices. Choices sometimes require the giving up of "favourite" traditional products, market areas, customers, domains of competence and operations.

The setting of higher-level goals in a company does not always involve formal strategic planning. The strategic goals of a small and medium-sized enterprise (SME) may be subsumed in the vision embraced by the owner-manager. What is important, however, is that the goals informing the development are made known to all. Even the lowest level of the decentralised decision-making system must be able to take into account the strategic goals.

3.1.1 Basic competitive strategies

Porter (1985) has presented the three basic competitive strategies which may be used to set up a defensive position in the long term or to beat a competitor in the branch. Companies which attempt to excel in all these areas will lose out to competitors who focus on excellence in the domain dictated by their basic strategy. According to Porter, the three basic competitive strategies are:

- cost leadership
- product differentiation
- focusing

Cost leadership requires that all activity strives in all ways to achieve cost leadership. A low level of costs in relation to competitors describes the overall strategy, although quality, service and other similar areas may not be neglected.

Product differentiation creates something unique within the entire branch. Differentiation can employ many approaches: product planning or brand image, technology, special features, customer services, retail network or some other feature.

Focusing means that action is concentrated on a certain customer group, segment of product line or a geographical area, and just as differentiation, focusing may take many forms. The strategy is based on the assumption that the company is capable of serving a narrow strategic target group better than the competitors who operate on a broader area. As a result, the company gains a competitive advantage either because of its better ability to meet the needs of a given target group, or of achieving lower costs in serving this group, or it may attain both these goals.

The US researchers Michael Treacy and Fred Wiersema have studied the success factors of market leaders in different fields (Treacy & Wiersema, 1995). Their results indicate that no company can succeed by offering everything to everybody. A company must find the unique value which it and it alone is able to offer on selected markets. In the value proposition to its customers, the company proposes to deliver a certain combination of added value. The company realises its value proposition through a value-driven operating model. If the value proposition represents the goal, the operation model represents the means. According to Treacy and Wiersema there exist three attractive ways in which companies can combine their operating models and value propositions to achieve a leading position in their preferred markets. These are called value disciplines. Choosing one value discipline over another does not mean that the two others are neglected; rather, the company thereby selects the dimension of added value on which its market reputation is based.

The value disciplines are:

- operational excellence
- product leadership
- customer intimacy

Operational excellence means advantageous prices and lower overall cost of product use and effortlessness.

Product leadership is based on products which are unsurpassed as to function, and because of which the branch expectations and performance will be redefined.

Customer intimacy means individual solutions customised to each customer.

The basis of the development model developed in this study corresponds to cost leadership and focusing in Porter's terms and to operational excellence and customer intimacy in Treacy and Wiersema's terms. However, the development of operational capabilities is not only based on the competitive strategy selected, since companies cannot neglect elements outside their competitive strategy. The operational capability of the existing order–delivery process must be continuously developed. Porter distinguishes between operational improvement and strategy (Hodgetts, 1999): "Operational improvement involves incorporating practices that would be good for any company – doing the same things as rivals but doing it better. Strategy is the pursuit of a unique way of competing. Strategy is choosing to deliver a particular kind of value, rather than just trying to deliver same kind of value better."

3.1.2 Production strategy

Production strategy will be discussed here to the extent necessary for understanding the background of the operational success factors of the order–delivery process presented later.

Hill (1992) describes the definition of production strategy as a series of discrete, successive stages:

1. defining company goals
2. deciding on marketing strategy
3. identifying competitive factors of products
4. selecting the most appropriate form of production for different product groups
5. defining the most appropriate manufacturing environment

According to Hill, the implementation of production strategy in an individual company does not necessarily begin at the top of the list and proceed down to the bottom.

Roth et al. argue for the importance of production strategy by saying that it is a critical component in world-class production (Roth et al., 1992). World-class competitors have defined clearly the grounds of their production strategies and plans. Their strategies are in alignment with the general business goals and sufficiently flexible to adapt to changes.

According to Skinner, the determining of a company's production strategy, derived from its competitive strategy and financial and technological potential, should take into account seven different performance goals (Skinner, 1992):

- Cost, efficiency, productivity
- Delivery lead times
- Quality
- Service, reliability
- Flexibility to product changes
- Flexibility to quantitative changes
- Investments required by the production system

In the late 1960s, Skinner developed the concept of trade-off, according to which a high performance in one of the production strategy performance goals is only possible at the expense of lower performance regarding other eventual goals. Skinner has later elaborated the concept (Skinner, 1992): trade-offs continue to be just as essential as they have always been, but they are live and dynamic. With the development of administrative and physical technologies, interactions change. Skinner claims that this is not so much a matter of trade-offs, but of interaction between different factors. Understanding the development of these connections and interactions is important. Since a system with a limited technology could never achieve maximal efficiency in all areas, the system must be so designed as to achieve the maximum in a few desirable areas.

In this study, the goal-oriented course of action is described on the basis of the selected *operational success factor* as part of the business idea. In the model developed, the order–delivery process is developed according to one selected operational success factor. The operational success factors presented are not wholly mutually exclusive, for it is possible to strive simultaneously for operating modes based on several.

3.2 Business idea

A company may slide almost unnoticed into a new and unfamiliar business area with new products, new customers or competitive and success factors which it does not know how to control. The situation becomes dangerous when different business areas require simultaneously different competitive and success factors. In this case, business development is hampered or skewed by the fact that there is no business idea or it has become blurred with all the change.

”It is a rare band that can play several tunes at the same time.”

A business idea must not be carved into stone, not to be criticised or doubted. Companies must continuously develop their business ideas. One of the surest ways of losing a company's competitive and result-making capabilities in the long run is to first define a good business idea and then, year after year, focus blindly on implementing it. Traditionally, the definition and revising of the business idea has been understood as strategic planning. It has traditionally been defined by answering the three basic questions:

WHAT? **TO WHOM?** and **HOW?**

The ultimate goal of every company relying on business principles is profitability. The means by which companies strive for financial success are linked to

QUALITY, **COST** and **TIME.**

These means are not listed here in any particular order. The business idea changes dynamically with changes in the company's environment. By defining the business ideas which correspond to different points in time of a company's life cycle, it is possible to gain a more concrete view of the changes which have occurred, which are to be expected and which are desirable in the concept of product, customer needs, customership and operating mode.

In order to direct and monitor the implementation of the business idea, we need key figures which describe the competitive and success factors defined as crucial in the business idea.

3.2.1 First definition of business idea; WHAT?

Answers to the question What? define the goal-oriented way selected to meet customer needs. What are the products offered and which are the factors by which the products meet customer needs and compete with other, similar products?

3.2.1.1 Products

A company’s capability of earning money is based on the capability of meeting customer needs by means of a product offered to the customer. In this way, the existence of a company is based on its capability of meeting the needs of its customers with its products. The company and the customer are linked by the product. The company's product policy determines the products which it offers to its customer. The product policy is affected by the size, location and growth potential of the corresponding market, the expertise and capacity existing in or accessible to the company, and the attractiveness of the business in question.

3.2.1.2 Competitive factors of products

In the market, the company faces competition since other companies also strive to meet the same needs of the same customers. *Competitive factors* describe factors with which the company's products compete on the market. The factors of product competitivity include *product quality, price* and *delivery time* (Figure 3.1).

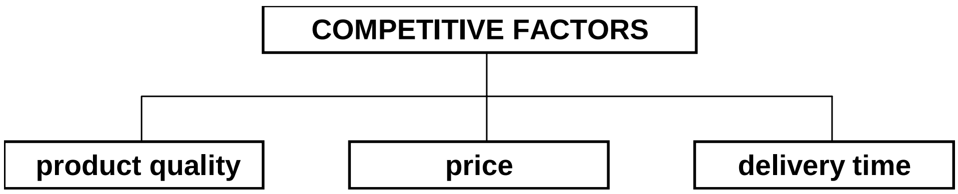


Figure 3.1 Competitive factors of products.

Product quality and delivery time as competitive factors are linked to how the customer sees the company's product and what benefit it brings to him; what is the value of the product to the customer. As described in chapter 2, customer value is the highest amount buyers are willing to pay for a product. The combination of customer value and price is crucial on the competition between different products. Competitive factors are relative, they describe the market position of a company's product in relation to similar competitive products. Competitiveness or competitive ability means that the company's products can meet the needs of a given customer segment better, more advantageously or more rapidly than its competitors without being decisively weaker than its competitors in any of these areas.

Product quality as a competitive factor

Product quality can be defined in several ways. According to Roth et al. (1992), product quality must be defined from the customer's point of view. Quality is what the customer says it is.

Lillrank (1990) divides the elements of a physical product's quality into three basic groups and describes their interrelations with the 'quality eye'. In this context, the elements of quality are taken to be:

- quality of design,
- quality of manufacturing and
- customer's quality image.

A corresponding approach can be applied to all product sorts. In the interests of universally applicable terminology, the concept *product realisation* is used instead of *product manufacturing* in this research report. Thus, Lillrank's original 'quality eye' can be presented in a more universal form (Figure 3.2):

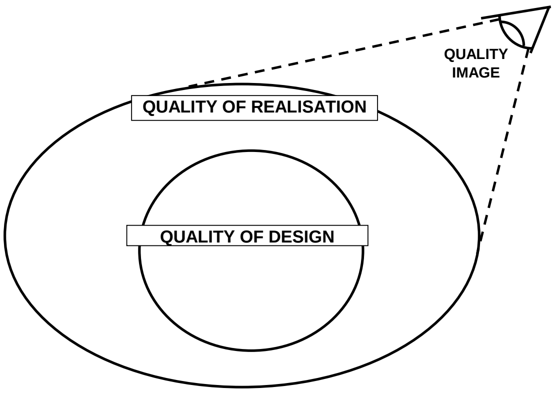


Figure 3.2 Adaptation of Lillrank's 'quality eye'. (Lillrank, 1990).

An essential measure of the quality of realisation is the uniformity of products. Uniformity equals homogeneous quality, the fact that all realised products are identical and give an identical performance. In the evaluation of product quality no attention is paid to the rationality and efficiency of realisation.

The elements of product quality increase the product's value in the form of a product feature or as a part of the added value of realisation or the image.

Product price as a competitive factor

The customer's needs are met by purchasing products. The customer's purchasing decisions are partly affected by the product's usefulness for the customer (customer value) and the cost caused by using the product. As regards cost, the first element evaluated is the price of the offered product. Other costs include costs caused by the product's use and maintenance. The product's customer value must be at least equal to the sum of costs caused to the customer by the product, because otherwise the customer will not buy it. The significance of product price as a competitive factor varies significantly according to product and market segment. Since the physical products and associated services offered by different companies are rarely completely identical, price comparisons may be difficult to make.

Delivery time as a competitive factor

Delivery time as a competitive factor means the speed meeting customer needs; the speed of realising and delivering the product ordered by the customer and the speed of developing and launching a new product to meet changed and developing customer needs.

The management of delivery time as a competitive factor also means adherence to agreements, the capability of delivering at the time agreed. In other words, time management as a competitive factor includes not only speed, but also control over the corresponding variability. The management of delivery times is closely linked to *reliability of delivery*. This indicates the probability of meeting the agreed delivery time.

The launching time of a new product, from the definition of need to the first customer delivery, and the delivery time of a product, from the order to the delivery, are increasingly frequently the decisive competitive factors in a tightening market.

Delivery time can increase the product's value in the form of added value of realisation.

3.2.2 Second definition of business idea; TO WHOM?

The business idea defines the groups whose needs the company strives to meet, those to whom it offers its products. What are the desired customer segments and geographical markets? At the same time, the business idea also defines the logistical chain or distribution channel used by the company.

3.2.2.1 Customer segments

The customers' purchasing requirements are heterogeneous. Companies are better placed to serve only certain selected customers and customer groups rather than all possible customers. Instead of attempting to meet any and all customer needs, companies should identify and find the market segments which they are best placed to serve. The definition of a functional business idea requires the identification of customer groups typical for the company. Since all customers cannot be served according to the same pattern, the overall market must be divided into smaller segments. The proper selection of customer segments to be served requires that customer needs are surveyed and the segments are appropriately limited and identified. It is essential to identify customer groups who desire the same products and appreciate the same competitive factors. The demand generated by the selected customer segments must be large enough to guarantee a sufficient volume through the market segment striven after.

The business ideas of Finnish companies frequently do not segment the overall market on the basis of different customer needs. If the customers are treated as an excessively wide, vague group, the business idea will remain vague and uninteresting and will not function well enough as the guiding principle. An example of this could be the companies which focus on manufacturing and/or trading in hydraulic components. If the market area is taken to be Finland alone, the simplest division into customer segments is the following:

- *Users of industrial hydraulics*. The competitive factors to focus on are linked to product quality; in terms of product performance, they are linked to positioning accuracy, product reliability and reliability of delivery.
- *Users of mobile hydraulics*. In competitive situations emphasis is placed on product performance, price and reliability of delivery.
- *Users of agricultural hydraulics*. Product price is practically the main criteria of selection.

In order to identify significant differences, this division would require more detail. Nevertheless, it may be said that a focus on the users of industrial hydraulics will certainly require different practical solutions from a focus on those who construct and use agricultural machinery.

If a company wants to serve several distinct customer segments, each of them requires a business idea of its own. Problems related to eventual conflicts between several business ideas should not be underestimated and a decision should be made concerning what to focus on and what, eventually, to give up.

3.2.2.2 Geographical market areas

In the interests of a proper focusing of resources and of achieving homogeneous customer segments, it is appropriate to limit the operation on defined geographical areas. The company needs to determine the customer segments and market areas which it strives to serve.

The functionality of the business idea may be evaluated by attempting to answer the following question: Among the potential customer in the defined market area, whose needs does the company NOT attempt to meet? If the answers are not absolutely unambiguous, the business idea is not clear enough. The limiting of customership is often prevented by greed: no potential deal should be excluded, or "the means are justified by the order". Such greed often becomes self-destructive. In trying to serve any and all, the company loses the opportunity of serving well and successfully customer groups which have been consciously selected.

In attempting to increase its markets, the company needs to be aware whether it is looking for growth by increasing its share in market areas and customer segments which it already knows, or attempting to expand its market area or acquire new customer segments.

3.2.2.3 Distribution channels

The distribution channel has a considerable significance as part of the logistic chain which creates customer segments. The company needs to know the end customer segments reached by its distribution channels and to ensure that these are, in fact, the groups which it wants to reach.

Distribution channels can have an influence on how much customers appreciate the offered value.

3.2.3 Third definition of business idea; HOW?

The answer to the question How? defines the goal-oriented operating mode of the company. How does the company produce added value? On what value and competitive strategy are the value-added operations of the company based? What are the factors on which the company's success, as measured by goal attainment, is based? The goal-oriented operating mode can have an influence on every component of product´s value.

3.2.3.1 Core competence

Success requires the skill of doing something at least equally well as or better than others. The fact that a company can distinguish itself from its competitors through its mastery of various competences does not guarantee success, but makes it possible. Success is more likely if the company strives to distinguish itself in one or a few aspects, to become a specialist of genuine core competence. All other things should be accomplished almost as well as the others, and this should lead to a superior end result.

Core competence means any skill, knowledge or capability which may be regarded as being of high level in comparison to the company's competitors. Success in business requires that the company itself or the value nets of which it is a member possess true core competences. The value net must make sure that the desired advantage over competitors and the value of the core competence are maintained. Core competence includes the following characteristics:

- enables entry to several different markets
- creates significant added value for customers
- is difficult to imitate by competitors

According to Rumelt, the following factors describe core competence (Olve et al., 1998, p. 39):

- the areas of core competence support several business functions and products
- existing products and services are only temporary expressions of core competence
- development input into the core competence is more long-term and stable than the development of products
- competence grows by being used
- in the long run, the competitive situation is determined by competence, not by products

Core competence is profound special competence which may be linked to, for instance, products, operations or the customer (Figure 3.3).

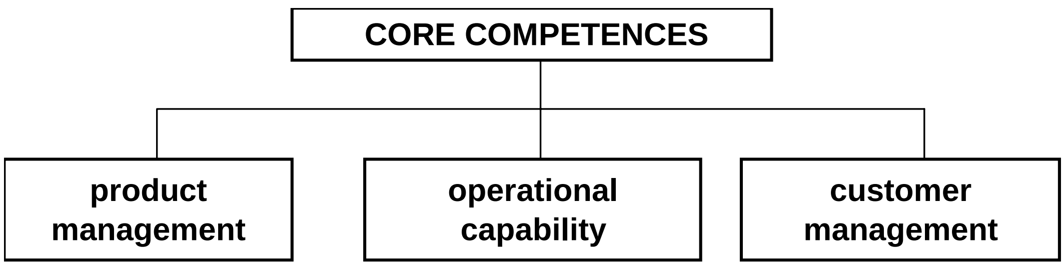


Figure 3.3 Segments of core competence.

The core competence segments striven after must be consistent with the value and competitive strategy selected. Similarly, the competitive ability resulting from the selected value and competitive strategy is created by core competence segments which support it:

value and competitive strategy	*segment of core competence*
product leadership	product management
operational excellence	operational capability
customer orientation	customer management

3.2.3.2 Networking

In the context of defining the business idea, the heading What? specified the products offered by the company to its customers. The product offering may contain items which the company must be capable of offering to its customers although it does not possess the competence and/or resources needed to realise them. Identifying one's core competence and focusing on it inevitably leads to decisions as to which operations the company should manage itself, which should be managed by partners sharing the same value net, and which might be given to actors outside the value net. In other words, the goal is to find the necessary core competence in one of the actors in the value net.

Networking and strategic outsourcing are not always based on core competences. In connection with a strong business growth or the start-up of new business functions, outsourcing may be a way of sharing resource-related risks. The company itself does not necessarily have the ability and/or desire to increase its capacity to meet the predicted demand.

3.2.3.3 Operational success factors

Success factors are linked to the company's internal actions. According to Lillrank, success factors are absolute; they describe the company's absolute level of competence (Lillrank, 1990). Because this study focuses on the development of the operational performance of the order–delivery process, examination is limited to the corresponding operational success factors. If necessary, the company's business idea should answer the following question:

> *Which operational success factor describes the goal-oriented operational capability of the order–delivery process?*

On a general level the success factors are related to *quality, cost* and *time* (not necessarily in that order). On the level of the order–delivery process, operational success factors signify operational quality, management of resource costs and speed (Figure 3.4). Flexibility, which is connected to every operational success factor, is discussed in more detail at the end of this chapter.

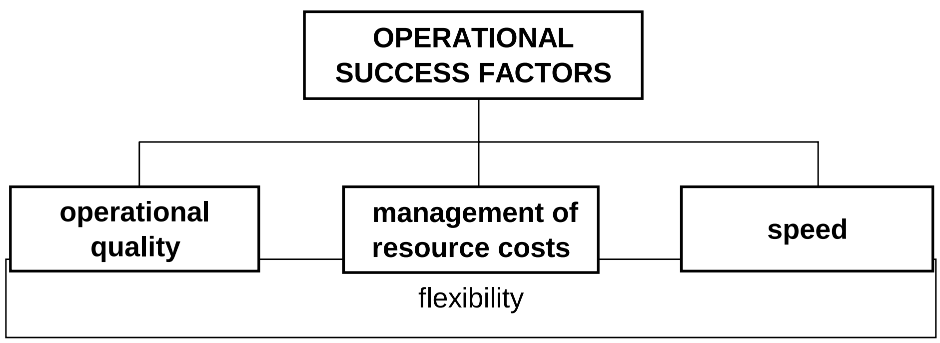


Figure 3.4 Operational success factors.

By managing the operational success factor of the order–delivery process, the company is able to support the competitive factors prioritised on the product-level; in other words, the management of operational success factors helps to create the prerequisites for competitive ability in the market. The choice of the correct operational success factor requires the management of customer-based competitive factors, of customer needs (Figure 3.5).

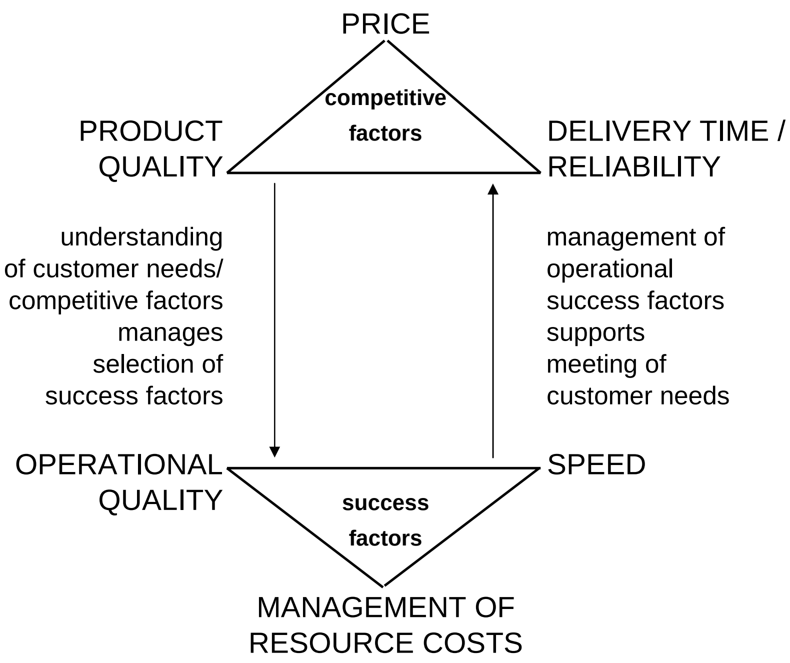


Figure 3.5 Interaction between competitive factors and operational success factors.

The operational success factors presented here support each other. However, within the model for developing the order–delivery process presented in this study only one factor at a time is selected as the critical one. A focus on one operational success factor when optimising the order–delivery process clarifies the development actions. When those developing the order–delivery process focus on one operational success factor at a time, the goal-setting linked to development will take an understandable and concrete form.

”*If everything is important,*
then nothing is truly important.”

The key figures linked to operational success factors describe the operational performance of the order-delivery process.

Operational quality as an operational success factor

Operational quality is understood as the capability of doing effective things efficiently.

> "Effective things" create products which are useful to the customers and appreciated by them, or they are useful from the point of view of the business process.
>
> "Doing efficiently" produces added value in a controlled and efficient manner.

The framework for operational quality is presented in Figure 3.6.

		OPERATIONAL EFFECTIVENESS	
		ineffective	effective
OPERATIONAL EFFICIENCY	efficient	ineffective things efficiently	effective things efficiently
	inefficient	ineffective things inefficiently	effective things inefficiently

Figure 3.6 Framework for operational quality.

A company which emphasises operational quality as an operational success factor pays attention to the controlled and efficient production of things which are useful to its customers, or which add value to the customers.

Management of resource costs as an operational success factor

The realisation of operations consumes resources, and resource consumption causes costs. On a general level, the resource costs of an operation are created as the result of amounts of resources consumed and unit cost of resources (Figure 3.7). The amounts of resources consumed are affected by the quality and speed of operation.

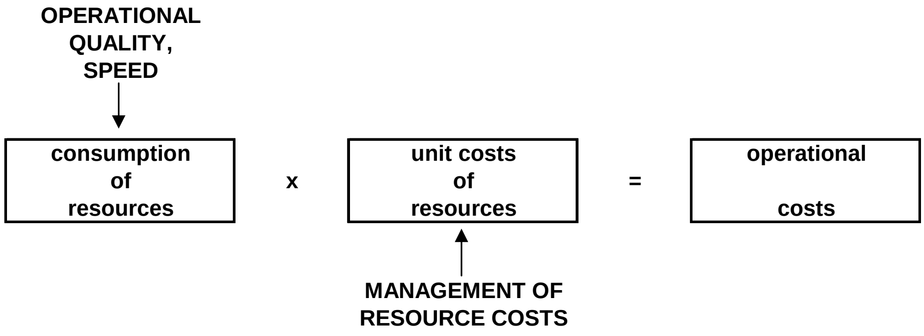


Figure 3.7 Composition of operational costs.

When a company focuses on the management of resource costs as an operational success factor, it pays attention to the unit cost of resources, or the economy of resources (prices paid for resources) and to the resource amounts available (resource adaptation).

Speed as an operational success factor

As was the case with costs and later with quality, time has become an important strategic success factor. The management of time as a success factor means the speed of implementing the company's core processes, the management of process lead times. Time management as a success factor includes not only the efficiency of speed and time consumption, but also the management of the corresponding variability. A focus on speed as a success factor does not simply mean a strive for short delivery times. A rapid process is more efficient than a slow one because of its smaller variability and better predictability. Rapid operation requires a firm grip.

When a company focuses on speed as an operational success factor, it pays attention to the length and management of the lead times of business processes.

Flexibility

Flexibility has become an important concept for all business activity. It is sometimes regarded as an end in itself, with no analysis of what kind of flexibility is needed and why. Flexibility in a general sense means the capability of adapting to changes in the environment.

From the point of view of profitable business, flexibility must be manageable. The customer needs which the company has decided to meet, with their variations, must be met in a controlled way. Flexibility may mean that standardised measures result in a great number of product variations based on modularity or the use of parameters.

Lapinleimu (2001) has drawn up a summary of literature on flexibility, and according to him, flexibility consists of two kinds:

- short-term operational flexibility with rapid activities and flexibility of capacity
- long-term capability of change in response to changes over time; despite its long life, production equipment must be adaptable

The concept of flexibility is always linked to time. Changes take place over time, and flexibility means the ability to respond to changes relatively rapidly. Therefore, flexibility is also always relative. In addition to speed, flexibility is linked to the efficiency of implementing changes. The smaller the effort needed to achieve the desired change, the more flexible the object examined is. Flexibility is also always linked to cost; in other words, the potential for flexibility must be paid for.

The concept of flexibility thus includes the three operational success factors presented above. The efficiency of change is comparable to operational quality or the appropriateness of operation with regard to change. Cost is linked to the price of change. As a concept, flexibility comes most closely to time management.

The flexibility of the order–delivery process is a complex feature, which may be acquired through investments, for instance. The key factor when defining flexibility is to highlight its different components. The company should recognise the components which it needs and should be capable of analysing which components are already good enough and which need further input.

3.2.4 Objectives of the order–delivery process

On the basis of the target-oriented operational capability as defined in the business idea, concrete, measurable goals may be derived for the operational performance of the order–delivery process. The following shows some examples of key figures used in this study in connection with operational success factors. The key figures are used to estimate such things as the adequacy of the development potential achieved by optimisation.

Operational Quality:

$$\textit{Process efficiency} = \frac{\textit{added value of process}}{\textit{process cost}} \qquad (2)$$

The concepts and key figures linked with operational quality are discussed in more detail in Chapter 8.

Management of resource costs:

$$\textit{Optimality of resource costs} = \frac{\textit{optimal resource costs}}{\textit{actual resource costs}} \qquad (3)$$

The concepts and key figures linked with the management of resource costs are discussed in more detail in Chapter 9.

Speed:

$$\textit{Process lead time} \qquad (4)$$

The concepts and key figures linked with speed are discussed in more detail in Chapter 10.

4 LEVELS OF DEVELOPMENT

Business development has two dimensions: strategic planning and the development of operational capabilities (Figure 4.1).

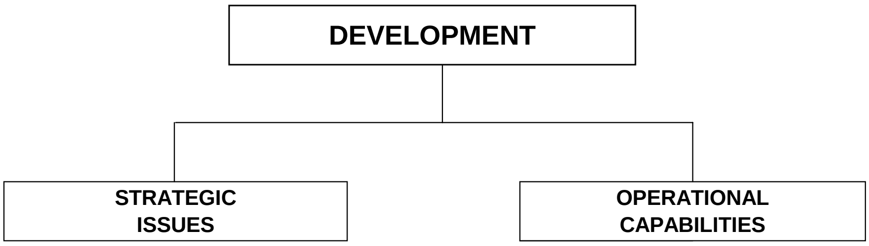


Figure 4.1 Dimensions of business development.

The targets and means defined in strategic planning are realised by the development of operational capabilities. In accordance to the definition of operational quality presented before, the main weight of strategic planning lies on *doing effective things*, while the development of operational capabilities consists of *doing things efficiently*. This chapter examines the development of operational capabilities and constructs a framework for the concept *optimisation*.

Business development strives for something *better* than the current state. In an extreme case, *better* means ideal. The perceived difference between *current* and *better* offers the opportunity for development. The need for development is created by the conscious strive after what is better. Problems are defined as obstacles for the realisation of this sought-after *better*. Development means

- problem awareness,
- problem analysis and
- problem solving.

4.1 Concepts associated with development

Variability

Variability includes everything that causes a system to deviate from a regular, predictable behaviour. Shewhart, Deming and Juran have divided both quality and production problems into two categories (Garvin, 1988; Juran, 1988). Shewhart describes the causes of variability in a process as either *assignable causes* or *chance causes*. Deming expresses the same thing using the terms *common causes* and *special causes*. Juran speaks of *chronic* and *sporadic problems*. In summary it may be said that variability is due to two things:

- **Common causes**
    - are a natural part of the system studied
    - cause the majority of variability in the system studied
    - their impact may only be lessened by changing the mode of production
- **Special causes**
    - are due to "external" factors which disturb the normal situation
    - may form an irritating problem which needs to be removed rapidly
    - if variability due to special causes is dealt with without proper consideration, the system will be over-controlled and its equilibrium will be disturbed

The disturbance variable may be a common cause inherent in the process and with a continuous influence, in which case it causes natural variability. The development actions envisaged to decrease variability must be directed to the mode of operation. The operation must be examined as a whole and improvements in its elements must be sought after. In general this means changes in the mode of operation or investments. (Salomäki, 1999)

A disturbance may be sudden and due to a special cause. A special cause is normally not inherent in the process. In general this is manifested as a peak outside the range of normal variability. The process itself must not be modified because of a disturbance due to a special cause. The cause must be identified, its impact on the process must be eliminated, and a means must be found to prevent its recurrence. After all this, the operation should proceed as before. The possibility of identifying a special cause depends on the degree of variability caused by common causes. The primary task of *statistical process control* (SPC) is to help identify and localise sudden problems of this type. Some examples of sources of variation:

Source of variability	Special causes	Common causes
Example	broken tool, dirty machine material fault, late delivery of material	unsuitable method, deficient training, poor layout, poor capability of producing quality
Correction	may be corrected locally	requires a change in the mode of operation

With the increase of knowledge, special causes may be distinguished from the noise caused by common causes, so that correcting disturbances due to the latter does not invariably lead to a change in the mode of operation.

Performance and process control

In the context of statistical quality control, the performance of a manufacturing process may be described by means of indices: process capability index C_p = process target requirement / process result. For products with established tolerances, the capability index describes the theoretical performance of the process in terms of the tolerance required. The six-fold process standard deviation estimate is compared with the tolerance range. Performance figures can only be calculated for processes which are under control and whose results come close to normal distribution. According to Laamanen (2001), performance is the ability to attain the results desired.

In this study, performance is evaluated on the basis of the goals set for the operational performance of the order–delivery process. Thus, the performance of a process which favours speed, for instance, is here measured by the process lead time.

A process is under control (Shewhart, 1980), if no special causes can be observed in it, and all variability noted may be interpreted as the result of sources which are inherent and internal to the process and have a continuous influence. Thus, a process under control behaves predictably. According to Laamanen (2001), a process is under control when no special causes affect its operation. A process of this type is not necessarily stable, but in the long run it may contain variation of its inherent characteristics, such as repeated fluctuation.

In the context of SPC a process is considered stable if its average and variation or, in a moving process, its direction and variation, remain practically unchanged. The variation around the average is only caused by common causes. A process may be stable even if it is not capable of performance, if the variability caused by common causes is too large.

In this study it is assumed that a process under control behaves predictably. As an example, the reliability of delivery of a process is a measure of process control or the predictability of the occurrence of the standardised process lead time. In a process not under control the variabilities caused by common and special causes cannot be separated.

4.1.1 Impulses for starting development

The first stage of business development is awareness of problems. If there appear to be no problems, there will be no need to solve one. Awareness of problems may arise in many ways, including:

- the existence of the organisation is threatened (battles for survival)
- the unit's competitiveness is threatened
- deficiencies which disturb operation have been noted
- a desire to eliminate recognised weaknesses
- business goals have not been met
- current operating mode does not comply with defined strategy
- operating environment has changed or is expected to change
- recognition of the fact that operation is not optimal in comparison to existing requirements
- a desire to utilise recognised potential
- a desire to improve existing strengths

4.1.2 Development objects

The objects of developing operational capabilities are the elements of operational business, as shown in Figure 4.2:

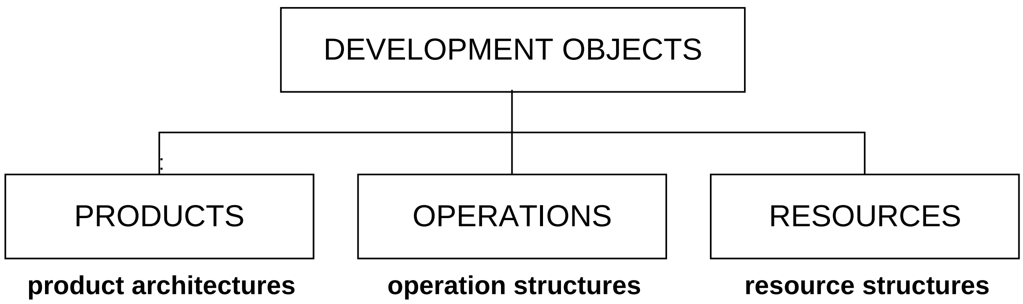


Figure 4.2 Development objects.

In the development of a product and/or a product architecture, development actions involve a physical product, a service or an information product or a combination of these. Correspondingly, in the development of operations and/or operation structures, the entities developed are work stages, tasks, activities, processes or value nets. As regards resources and/or resource structures, possible measures include developing, increasing or renewing resources, improving their performance or the revision of resource structures.

Since the product is the object of business activity and a means for satisfying customer need, it may be regarded as the primary development object. In this study, the product is regarded as given and as stable from the point of view of development, and the focus lies on operations, on the realisation of products. In this study products and resources are discussed as elements of operations.

4.1.3 Resources of development

Development involves all those working in a value net. The responsibility of each person working in the value net cannot be limited to the operational performance; each of them must also be responsible for developing their own work. The resources responsible for carrying out distinct (project-based) development actions may include:

- those involved in operations, in addition to their normal work
- permanent parallel development organisations
- project-specific development teams
- in-house development specialists
- external experts

The role of experts is defined variously according to source. A basic division of consultancy is the following: (The European Handbook of Management Consultancy, 1995):

- expert consulting and
- process consulting.

An expert possesses in-depth knowledge of a certain domain and provides the company with advice directed at solving perceived problems. The aim is to find the "correct" solutions. A process consultant supports the company during a problem-solving and development project, assisting the company to solve its problems.

4.2 Levels of development

Various sources define the ways of development variously depending on the degree of change sought after, or on the difference between current state and target state.

Imai divides development into maintenance and improvement (Imai, 1986). Improvement is further divided into *continuous improvement* (KAIZEN) and *innovation*:

- **maintenance** aims at maintaining technological, administrative and operational standards
- **improvement**
    - **KAIZEN** aims at improving standards through small improvements
    - **innovation** involves radical changes as a result of extensive investments in technology and/or equipment

By KAIZEN, Imai means a continuous improvement of personal, home and social life and working life in general. At the workplace, KAIZEN means continuous improvement which involves everybody – management and workers alike.

The process development guide published on the Internet by the U.S. Department of Defence (Department of Defence, 2001) present three clearly distinguishable ways of process development, each with their own special features and organisational impacts:

- **Continuous Process Improvement** (CPI). Improvements are incremental and sustained. CPI actions typically are wholly contained within one functional activity. *People* and how they perform their jobs is the focus.
- **Business Process Redesign** (BPR). The focus is on streamlining processes by detecting and eliminating non-value added process time and costs, and incorporating best practices in whole or part. *Process* is the focus of improvement efforts.
- **Business Process Reengineering** (BPR). BPR actions are radical and transforming. *Technology* assumes primary importance.

Laamanen (2001) has determined three improvement concepts for process development, all characterised by process description, measuring and analysis, and testing of solutions:

1. process planning and performance improvement
2. problem solution
3. benchmarking

In the Toyota production system, all actions are clearly defined as to their performance, order, timing and end results. All doing is disciplined and committed to following defined standards. Deviations are not accepted. A deviation will immediately lead to corrective measures. All improvements are carried out using a specified format, on the lowest possible level of organisation. (Spear & Bowen, 1999)

According to the ISO 9004 standard, the strategic objective of an organisation should be continuous improvement in order to improve performance and benefit interested parties (ISO 9004:2000) and there are two fundamental approaches for improvement activity:

a) “Strategic breakthrough projects which lead to revision of existing processes, or the implementation of new processes, usually carried out by cross-functional teams outside routine operations.”

b) “Small-step continual improvements made by work teams with existing processes.”

According to the ISO 9004 standard, breakthrough projects should be managed by project management principles.

As a summary the above, the definition used in this study for the levels of development of operational capabilities is presented in Figure 4.3.

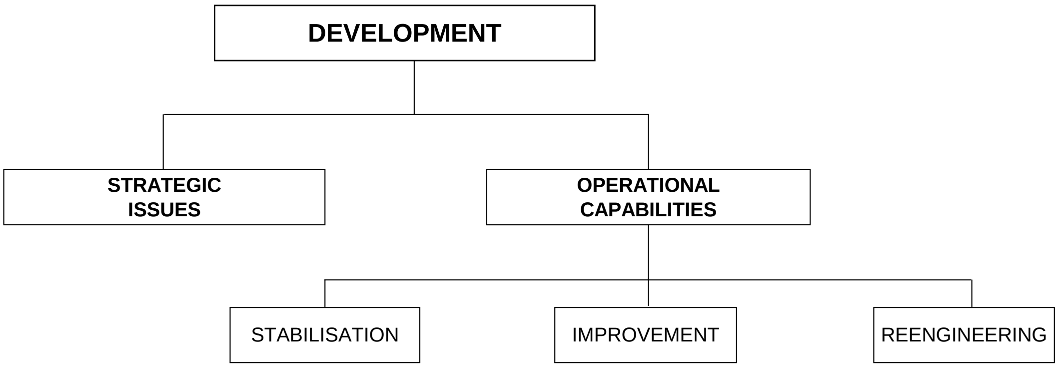


Figure 4.3 Levels of development of operational capabilities.

Stabilisation. The aim of stabilisation is to bring the operation being developed under control so that its performance is predictable. In stabilisation the main weight lies on problem perception. The aim of stabilisation is to bring process maturity to level *4 – Managed*.

Improvement. Operations under control are improved in small steps. The main weight lies on problem analysis. Process optimisation requires the corresponding maturity level of the process, *5 – Optimising*.

Reengineering. Reengineering means a radical, one-off improvement of the performance of the operation being developed. In reengineering, the main weight lies on problem solution. Self-directed renewal requires a very mature process, of level *6 – Reengineerable*.

4.2.1 Stabilisation

The aim of stabilisation is to remove ambiguity from the development object and to bring it under control. In this study the aim of stabilisation is to bring the operation studied under control so that its performance is predictable. Bringing the operation under control requires standardisation, which is used to eliminate the special causes affecting the operation.

In Japan, continuous improvement is closely linked with the PDCA (Plan-Do-Check-Act) circle, which describes the measures needed to achieve improvement. It was W. Edwards Deming who encouraged the Japanese to adopt this systematic approach to problem-solving (Garvin 1988). "Plan" denotes the planning of improvements, using statistical methods, such as the seven quality tools. "Do" denotes the implementation of the plan. "Check" denotes the verification of the implementation. "Act" denotes the stabilisation of the improvement as practices, standards, which may be further improved. According to Imai (1986) it is necessary to stabilise standards before starting continuous improvement. The stabilisation process is called the SDCA (Standardize-Do-Check-Act) circle. Only when the SDCA circle is operating can the current standards be improved on the basis of the more universal PDCA circle.

The performance of an operation cannot be defined or improved unless it is stable. Although an operation is under control, its performance can still be poor. An operation under control does not necessarily meet its performance targets. If it is sensed during process stabilisation that, despite optimisation, the current mode of operation will not meet its performance targets, it is worth thinking of starting a re-engineering project. The situation is made more difficult by the fact that the true performance of a process can only be assessed after the process is under control.

Problem awareness

In stabilisation, the main weight lies on problem awareness. What are the special causes leading to operational variability, due to which the operation studied is not under control and its performance is not predictable? Poor predictability means, for example, the inability to control the capability of producing quality, a poor predictability of actual costs, or poor reliability of delivery.

According to the standard SFS 3750 a *fault* is a situation in which the operation of an object deviates from the operation specified. When the object is a system, a fault is often called *(operational) disturbance*. According to definition, disturbance identification is preceded by the definition of the operation of the object studied. Thus, problem awareness is linked to an awareness of the goals of business and the operation studied, and to the definition and description of the operating mode which corresponds to the goals specified.

Problem analysis

In the context of stabilisation, the main weight of problem analysis lies on an analysis of special causes. Randomness is defined on the basis of which elements and characteristics of the operation studied are in line with the targets set (included in standards) and which are not.

Problem solving

According to Imai (1986), it is the management's task to draft the standards and to set up the systems maintaining them. Only after that is it appropriate to introduce KAIZEN to improve the standards.

In practice, the stabilisation of operations means writing the appropriate instructions and enabling the repeatability of procedures. In these tasks the operational systems and quality systems have an essential role.

4.2.2 Improvement

The development of customer needs and changes in the business environment require a continuous improvement of performance. Neglecting continuous improvement will lead to regression: others will leave the company behind. Improvement helps to maintain and strengthen positions.

The aim of improvement is to reach a state where an operation under control can achieve the optimum performance enabled by its elements and, at a minimum, to maintain performance level in the face of actual and anticipated changes in external elements.

The ISO 9004 standard divides improvement into corrective and preventive actions (ISO 9004:2000). Corrective actions should be focused on eliminating causes of nonconformances and defects in order to avoid recurrence. Organisation should use preventive methodologies to identify the causes of potential noncorformances. The organisation must continuously and actively improve its processes, instead of simply waiting for improvement opportunities associated with emerging problems.

In this study, improvement is divided according to Figure 4.4, into *corrective improvement*, *optimisation* and *proactive improvement*.

The use of the concept *Continuous Improvement (CI)* found in Japanese quality management varies widely. In this study it is understood that continuous improvement consists of both corrective improvement and optimisation. The traditional form of corrective improvement has been to encourage self-directing teams to carry out improvements on the task level.

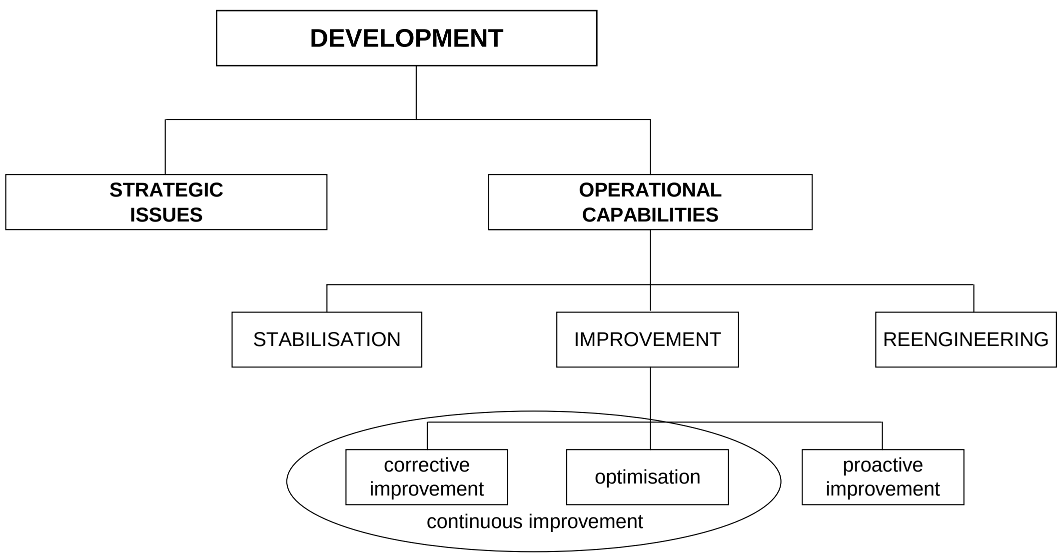


Figure 4.4 Types of improvement.

Characteristics of corrective improvement, optimisation and proactive improvement have been presented in Table 4.1.

Table 4.1 Characteristics of corrective improvement, optimisation and proactive improvement.

	corrective improvement	optimisation	proactive improvement
	continuous improvement		
resources	development teams formed of the function's employees (in addition to normal duties) (quality circles, CI-teams)	appointed cross-organisational development teams	development professionals
methods used	traditional set of seven quality tools	benchmarking, case-specific analyses to identify factors which deteriorate performance	proactive methods to identify causes of potential faults, such as failure modes and effect analysis (FMEA)
goal	eliminating variability due to special causes, reducing variability due to common causes	elimination of useless elements, structural optimisation, optimisation of value adding elements (performance)	prevention of problems and problem identification before they cause disturbances

4.2.2.1 Corrective improvement

In corrective improvement the main weight lies on reducing the variability of the development object which is due to common causes. Eliminating variability requires that its sources are identified. Corrective improvement comes very close to traditional *continuous improvement*. In the context of stabilisation of activity much weight was placed on eliminating variability due to special causes. In connection with corrective improvement at the latest, the "requirements for carrying out the work" must be guaranteed and the final traces of these obstacles to development must be removed.

In traditional continuous improvement the main focus lies on removing existing problems, *correcting* the situation. These problems due to common causes may be so familiar that without specific analysis (the seven traditional quality tools) the organisation may not even realise that they are problems.

In 1976, the Japanese Society for Quality Control defined the Seven Management (New) Tools (Mizuno, 1988), which are not in very widespread use. The seven new management tools do not focus as exclusively on corrective improvement as the traditional quality tools. The new management tools may also be profitably applied in optimisation and proactive improvement.

Problem awareness

KAIZEN begins with the problem, or rather, with problem awareness (Imai, 1986). If there are no problems, neither are there opportunities for improvement. Tools which may assist in problem awareness include:

- flow chart,
- check sheet,
- pareto diagram,
- cause and effect diagram (fishbone, Ishikawa),
- process capability assessment,
- affinity diagram.

Problem analysis

In corrective improvement, problem analysis stresses the mutual weighting of common causes and the more detailed analysis of factors behind common causes. Following is a list of some suitable tools:

- histogram,
- control chart,
- pareto diagram,
- cause and effect diagram (fishbone, Ishikawa),
- scatter plot,
- relations diagram,
- tree diagram and
- matrix data analysis.

Problem solving

In corrective improvement, problem solving means the elimination of known problems.

4.2.2.2 Optimisation

The aim of optimisation of the development object is to reach best accessible performance level within the constraints posed by other development objects. According to the process development guide published by the U.S. Department of Defense (2001) the redesigning of a business process takes place in projects which deal with planned or special improvement objects. The goal is to streamline processes by identifying and removing non-value-added process time and costs and by employing the best available practices. The goal of these projects is often a moderate improvement of the quality of end products and services.

Problem awareness

In the context of optimisation, problem awareness is based on awareness of optimal performance. The assessment of what is optimal is primarily based on *benchmarking*. If benchmarking on a company level is impractical, theoretical benchmarking will be employed. In this study, *optimality* measures the relative proximity of actual performance to optimal performance. In the context of optimisation, the differential between optimal and actual performance may be termed a problem.

Problem analysis

In the context of optimisation, problem analysis focuses on identifying the factors (weaknesses) which prevent optimal performance. Weaknesses prevent or hinder the optimal use of strengths.

Problem solving

In optimisation, problem-solving focuses on eliminating identified weaknesses, on bringing operation to the optimal level.

4.2.2.3 Proactive improvement

Proactive improvement strives for an awareness of problems before they become actual.

Problem awareness

Some examples of methods suitable for identifying potential problems include:

- risk analyses,
- trend analyses and
- statistical process control (SPC).

Problem analysis

Some examples of methods suitable for identifying the causes of potential problems include:

- fault tree analysis,

- failure modes and effect analysis (FMEA),
- Process Decision Program Chart (PDPC) and
- arrow diagram, activity network diagram.

The FMEA is a systematic method for analysing the possible fault states of products and processes and their effects. The FMEA technique is primarily envisaged as a preventive tool to remove design and planning errors and to guide planning decisions between various options. Faults are given scores on the basis of the probability of their occurrence, fault severity and probability of detection. The point scores of each fault are multiplied by each other to give the Risk Priority Number (RPN). The RPN is used to direct planning first of all to the most critical faults; the faults with the highest priority number will be eliminated completely as far as possible.

Problem solving

In proactive improvement, problem solving may be affected by the following factors:

- probability of problem occurrence,
- criticality of problem and
- cost of problem elimination.

4.2.3 Reengineering

Reengineering can be applied to all development objects and to operations of any size. Reengineering is often connected to the whole business process. The reengineering of business processes provides a response to dramatic changes in the environment which cause considerable pressure on the organisation's ability of realising its mission, improving its competitive position or surviving at all (Department of Defense, 2001). Reengineering measures are radical. They are targeted to overall processes which affect the whole organisation, or important parts of such processes. Reengineering has an impact on the operation of all departments. The reengineering projects are initiated and steered by the top management. Cross-organisational teams are organised and led with the support of top management.

Hammer and Champy have defined reengineering as follows (Hammer & Champy, 1993): "The fundamental rethinking and radical design of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed" Reengineering is justified only when truly massive measures are required. Marginal improvements require fine tuning, whereas decisive improvements require the old structures to be blown away and something new to be built instead. The failure of reengineering is most frequently caused by a failure in its management (Hammer & Champy, 1993).

Problem awareness

In the context of reengineering, problem awareness means perceiving radical problems linked to the performance of the value net and, on the other hand, perceiving and anticipating major changes in customer needs and/or the competitive situation.

Problem analysis

In selecting the processes to be reengineered, companies use three different criteria according to Hammer (Hammer & Champy, 1993):

1	Operational disturbance	Which processes exhibit the greatest problems?
2	Importance	Which processes have the greatest impact on the company's customers?
3	Suitability	Which processes currently provide the best potential for successful reengineering?

Customers are a good source of information for comparing the relative importance of different processes (Hammer & Champy, 1993). Companies are able to determine the issues which are truly important to their customers – such as product cost, punctual delivery, product properties, etc. These issues can then be linked to processes which affect them most, when defining the internal priority of processes in need of reengineering.

Problem solving

In the context of reengineering, problem-solving is clearly prioritised.

In reengineering projects, the potential awarded by IT is of great importance. It enables the reorganisation of operations and the elimination of constraints caused by time and space.

4.3 Priority of development

Development begins from bringing the development object under control. A stabilised object of development may be improved and, when necessary, reengineered. Among objects of developments, products are the most important, because they form the starting-point of operations, the object of doing. The product defines the operations needed. Correspondingly, the necessary resources are determined by the operations to be realised. Controlling and improving the product creates requirements and conditions for controlling and improving operations. After this, resources may be selected and developed appropriately. The development of a match between the product architecture and the operation and resource structures forms a separate object of development. In general terms, the general order of priority in developing operational capabilities may be presented as in Figure 4.5.

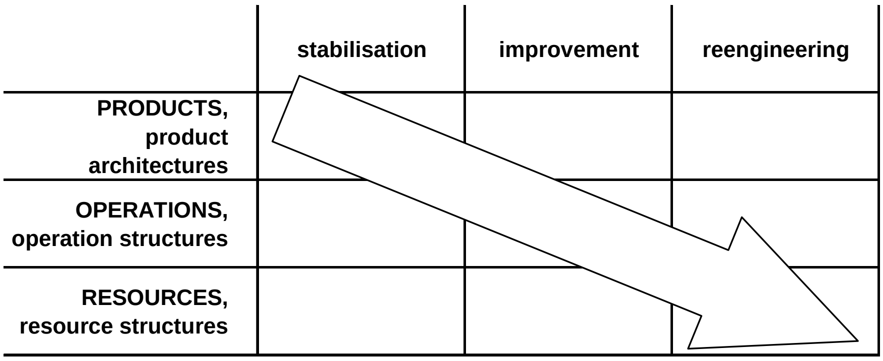


Figure 4.5 General order of priority in developing operational capabilities.

4.3.1 Cycle of development

The levels of development follow each other in a cycle, resembling the PDCA circle. The development of an uncontrolled object must be started by stabilising it. Once an object is under control, it will begin to be improved almost by itself. Since the results achievable by improvement are limited, the object must be reengineered from time to time. After reengineering, the object needs to be stabilised again, and so on.

Figure 4.6 shows the elements of the PDCA circles as a rough indication of the priority at each development level.

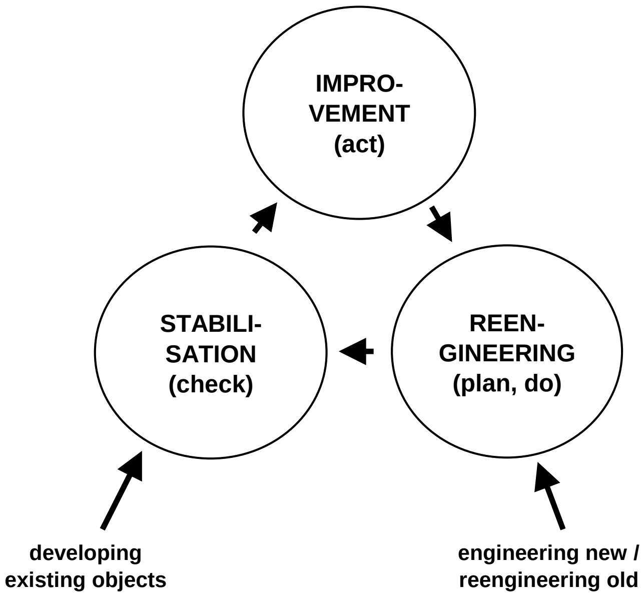


Figure 4.6 Development actions of different levels succeed each other from time to time.

If there is a vision and a strong leadership in the company, it may be appropriate to bypass the lower levels of development and "jump" directly into the reengineering phase, which will then be followed by stabilisation and improvement.

PART II:

STATE OF THE ART

5 EXAMINING METHODS OF IDENTIFYING DEVELOPMENT OBJECTS

This chapter deals with an essential part of development, that is, problem analysis. The main emphasis is placed on the identification of appropriate development objects. The chapter examines and evaluates methods in general use which enable the identification of development objects in the order–delivery process. The chapter concludes with arguments for further research.

5.1 Criteria for examining methods of identifying development objects

The selected methods of identifying development objects are examined on the following criteria:

- goal orientation of development,
- systematic identification of development objects,
- concreteness of development proposals and
- process-basedness.

This criteria is based on the research problem and the goals defined for this dissertation.

5.1.1 Goal orientation of development

As stated in Chapter 4, development begins with an awareness of the existence of problems. One of the requirements for methods of identifying development objects is that problem awareness is created through the upper-level strategic goals of the entity studied.

Chapter 8 examines the concept *quality of operation* in more detail. On the general level, quality of operation is understood as "doing effective things efficiently". In the context of developing operational business, it is justifiable to say that development actions which implement the strategic goals of the company are the effective things. The methods for identifying objects of development which are studied in this research are required to be *goal-based*.

It should be noted that many of the development fads are based on assumed goals for the development and emphasise different competitive and success factors at different times. Methods of this type are primarily a typical solution for a generally known disease, rather than a system which provides a coherent guide towards the appropriate development actions on the basis of the goals of each case. An example of this is Time Based Management (TBM), which aims at significantly shortening the lead times of business processes without analysing either the company's business goals or the basis of its competitive ability.

The degree to which the methods of identifying development objects support this criterion is assessed in this study using the following scale:

- *good support*; the goals of development are clearly and unambiguously derived from higher-level strategic goals,
- *partial support*; higher-level strategic goals may be taken into account, or
- *poor support*; the method does not pay attention to the definition of goals for the activity.

5.1.2 Systematic identification of the development object

The concern here is to assess the extent to which the methods selected support problem analysis. The methods for identifying development objects are evaluated on the basis of whether they include a formal and systematic analysis of perceived problems.

The methods for identifying development objects are assessed according to whether they are based on systematic formal analyses.

In assessing the systematic of a method the model also considers whether it functions better in a *management* or a *leadership* culture. A *management* culture supports objective analysis based on facts. As business processes are brought under control and process maturity is increased, the inherent weight of different management activities increases. They help to ensure discipline and control of activity. *Leadership* involves strong personal leaders and visionary qualities. Leadership is a personal characteristic. A strong leader may achieve significant development results and be capable of genuine reform on the basis of his or her visions. The model described in this study strives away from a dependency on strong leadership and towards management and a systematic, analytical approach.

The degree to which the methods of identifying development objects support this criterion is assessed in this study using the following scale:

- *good support*; using the formal and systematic analyses included in the method, the same end result can be achieved independent of the analyst,
- *partial support*; some analyses are utilised in the definition of development objects, or
- *poor support*; the identification of development objects is not based on an analysis of the current situation.

5.1.3 Concreteness of development proposals

After the identification of the development objects with the help of analyses, the process of development needs information on what to do about the objects identified. The development methods are assessed on the basis of whether their application produces proposals for concrete and sufficiently detailed development actions which are suitable for the order–delivery process and will increase the operational capabilities of the business in line with its established goals.

The degree to which the methods of identifying development objects support this criterion is assessed in this study using the following scale:

- *good support*; the method under study generates a detailed and concrete proposal on the development actions needed,
- *partial support*; the method provides partial support in identifying the necessary development action, or
- *poor support*; the method cannot be used to identify action needed for development.

5.1.4 Process-basedness

Finally, the methods of identifying development objects are assessed as to whether they are suitable for an approach following the actual process. In the 1990s, approaches focusing on a study of operations began generally to be called *process-based*. The advantages of a process-based approach could be said to include the following:

- a process-based approach leads to the examination of coherent wholes,
- version 2000 of the ISO quality system is based on the process approach,
- a process-based and cross-organisational approach helps to decrease the risk of partial optimisation, which is present if departments are examined separately and
- because business processes exist to produce added value to customers, process-basedness includes customer orientation.

The degree to which the methods of identifying development objects support this criterion is assessed in this study using the following scale:

- *good support*; the method is based on a process-based approach which observes the real process,
- *partial support*; the method pays some attention to business processes or other corresponding approaches, or
- *poor support*; the method does not pay attention to business processes or corresponding operation structures.

5.2 Methods of identifying development objects selected for assessment

The methods selected for assessment include methods which are or could be used in identifying development objects in the order–delivery process in the context of independent development projects. Approaches which are closely linked to daily operational activity are excluded. Thus, the selection does not include such methods as *CI*, *JIT*, *Quality Circles* (QC) or *SPC*.

The following methods for identifying development objects are examined:

- Activity-Based Management, ABM,
- Business Process Reengineering, BPR,
- Business Development Using New Technology, BUNT,
- Self-evaluation, EFQM,
- Juuri Oikeaan Tarpeeseen, JOT,
- Manufacturing System Design Decomposition, MSDD,
- Six Sigma, SS,
- Supply Chain Operations Reference-model, SCOR,
- Theory of Constraints, TOC,
- Productivity Analysis, TUOTTO^{+} and
- Value Stream Mapping, VSM.

Following is a brief assessment of the methods selected. A summary of the assessment is presented in Table 5.1. It should be noted that it is impossible to provide a clear-cut assessment of these methods, as the original concepts of all of them have been considerably modified later and all exist in several versions.

5.2.1 Activity-Based Management, ABM

Activity-Based Management (ABM) was created in the context of Activity-Based Costing (ABC) in the early 1990s (Brimson, 1992). Activity-Based Management makes use of the basic data provided by ABC. The most significant difference between the two is that ABC focuses on cost calculation, whereas ABM focuses on continuous improvement of operation by means of activity analysis, cost drivers and performance measures (Lumijärvi, 1993).

The main emphasis of ABM lies on optimisation. Activity analysis is used to identify and discontinue non-value-added activities and to focus on value-added activities.

Goal orientation of development

The aim of ABM is to improve cost-efficiency. The key figures are often based on the results of Activity-Based Costing. ABC and ABM may be used to support the implementation of strategic plans. However, this is not so much an inherent, systematic characteristic of the method as a result of how it is applied.

Systematic identification of development objects

The activity analysis underlying ABM may be used in one-off development projects as a method for identifying development objects. The activity analysis generates information which can lead to identifying unnecessary, overlapping and wasteful activities and cost-creating factors (Brimson, 1991).

Activity-based cost calculation leads to a battle against wasteful use of company resources due to a random allocation of costs. The potential for cost savings is revealed by analysing non-value-added activities and finding best solutions. What is essential for an improvement of profitability and efficiency is to identify the purposes for which the company time is used and to understand in detail what the company does and how it does it. (Brimson, 1991).

Systematic is realised in ABM to a moderate degree only. The method itself may be regarded as analytical, but the analyses are not systematically derived from the company's higher-level goals.

Concreteness of development proposals

Activity-specific cost and performance data together with detailed product-specific cost data enable the management to improve business, eliminate waste, identify causes of cost, plan action and build business strategies (Brimson, 1991). ABM is used to measure and systematically select actions required for success and to survey from time to time the success of implementing them (Jolkkonen, 1993). In sum, it may be said that in itself the method does not generate concrete development proposals. Rather, its principle is that the answers to the question "Why are costs incurred?" guide towards the appropriate development objects and actions.

Process-basedness

ABM may be regarded as a preliminary stage of a more general process management. ABM may be regarded as process-based: the method examines activities and processes built up of chains of activities.

5.2.2 Business Process Reengineering, BPR

Business Process Reengineering was a popular approach to business development in the early 1990s. Process reengineering easily leads to failure, as the approach requires a strong leadership. Even without a reengineering leader, it is possible for a company to conduct paper research and even set up new concepts of process planning, but without a personal leader, reengineering will not be possible in practice. ”Companies that have reengineered don't want employees who can follow rules; they want people who will make their own rules.” (Hammer & Champy, 1993)

Goal orientation of development

In the context of this study the method is not regarded as fully goal-based, since the goal orientation is not unambiguously based on strategic goal-setting. The purpose of process re-engineering is to create a process which meets customer needs better than previous ones (Hammer & Champy, 1993).

Systematic identification of development objects

The main weight of the analyses lies on the selection of processes to be reengineered. Companies are able to determine the things which genuinely matter to their customers – such as product costs, punctual delivery, product features, etc. These things may then be linked to the processes which most affect them, when determining the internal priority of processes in need of reengineering. (Hammer & Champy, 1993).

A company which first looks for problems and then attempts to find solutions for them is not capable of reengineering. The purpose of process reengineering is to understand what happens in a process and why, not how it happens. The reengineering team is more interested in what the new process should achieve than how the current process works.

Concreteness of development proposals

As a method, Business Process Reengineering does not propose concrete development objects within the existing process.

Process-basedness

As can be seen from the very name, Business Process Reengineering is a fully process-based approach to business development.

5.2.3 BUNT

The method of identifying development objects which is called BUNT in this study is originally based on a programme developed in Norway to improve the competitiveness and development prerequisites of SMEs (The European Handbook of Management Consultancy, 1995). The acronym BUNT is based on the original name of the Norwegian development programme (Business Development Using New Technology). The purpose is to recommend to companies changes based on a strategic analysis or other data. BUNT is a holistic approach to sort out a company's problems and direct the solution process.

Work with BUNT begins with what are called *issues*; after that the interest moves on to an evaluation of possible solutions (*options*), and the final result is a unified hierarchy of goals, strategies and measures. The issues define something which requires a decision – not necessarily because it is currently a problem, but because something has not been solved.

Goal orientation of development

In BUNT, the purpose of strategic analyses (business analysis, key ratio analysis, product/market analysis, structured interviews) is to clarify where the problems lie, and to define the framework and limits for subsequent analyses: "What is of primary importance for the company?" Setting priorities without strategic analyses may, at best, lead to partial optimisation, at worst to incorrect prioritisation.

Other methods, such as activity analysis, focus more closely on areas which are believed to have the greatest impact:

- the company's cost position,
- attainment of company goals and
- better compliance with the customers' purchasing criteria.

Systematic identification of development objects

As a method, BUNT is extremely analytical. Numerous analyses are carried out. The early identification of critical issues directs the analyses to the appropriate domains. During the analysis, the issues and solutions are grouped according to how far they meet the major criteria. The prioritisation process consists of structured interviews and numerical methods, prioritisation matrices. Operational analyses include activity, information, material flow and the traditional Strengths–Weaknesses–Opportunities–Threats (SWOT) analyses.

Concreteness of development proposals

The method itself does not generate concrete development proposals. It contains an approach for identifying development objects. BUNT stresses the fact that numerical values are not a substitute for common sense. The aim of the prioritisation process is to identify the problems most critical for the company and the most appropriate solutions to them.

Process-basedness

BUNT may be considered a process-based approach because one of the objects of analysis are activities and the value chains formed by them. By comparing the company's value chain to the established goals and purchasing criteria it is possible to form a matrix showing the connections between purchasing criteria, company goals and activities.

5.2.4 Self-evaluation, EFQM®

The European Foundation for Quality Management (EFQM®) presents the annual European Quality Award and encourages organisations to conduct self-evaluations using the EFQM model. The aim of the self-evaluation process is to provide the organisation with a concept of its strengths and areas of improvement. The organisation is evaluated in nine different areas; in combination, these describe the excellence of operation from the point of view of achievements and capabilities.

The self-evaluation is supported by a set of questions (EFQM 2001). The questions are designed to help the organisation to define the level of excellence of its business, and are based on a tested method.

Goal orientation of development

The evaluation is not designed to identify concrete development objects derived from higher-level goals, but the purpose is to become aware of the capability of the management system in the unit evaluated for guiding development. In self-evaluation, attention is primarily focused on the company's management system instead of on the operations themselves. On the other hand it may be noted that, according to the principles underlying the set of questions used in the evaluation, such issues as the shortening of lead times are essential goals from all business viewpoints.

Systematic identification of development objects

The method may be considered extremely analytical on the qualitative level. The analyses carried out are only partly based on measured, quantitative data.

Concreteness of development proposals

The purpose of the self-evaluation based on a set of questions is to provide an overview of current situation rather than a recipe for areas to be improved. The questions with the weakest answers are the most likely to need improvement. However, the final decision on improvement actions depends on several factors, of which aspects related to the organisation's business and culture are among the most important ones.

Process-basedness

Self-evaluation may be considered a process-based approach. "Processes" is one of the five "activity" evaluation areas, which are used to examine the appropriateness and consistency of procedures. According to the principles underlying the set of questions, the concept of internal customership must be clear; every employee and department has its own internal customers (EFQM 2001).

5.2.5 Juuri Oikeaan Tarpeeseen, JOT

In this study JOT (based on the Finnish words Juuri Oikeaan Tarpeeseen = Just for the Right Need) means a method developed by the Technology Industries of Finland (formerly the Federation of Finnish Metal, Engineering and Electrotechnical Industries), based on the Just In Time philosophy (Metalliteollisuuden Keskusliitto, 1984). The key goal of JOT production is to eliminate all unnecessary aspects of production. According to this approach the management has two options for proceeding in production development. Certain areas of JOT production may be selected for separate improvement measures, or the production may be converted thoroughly according to JOT principles. This requires a joint decision and the support of all employee groups in the company. Moreover, the management must create the technical prerequisites and opportunities for implementing the change. In implementing the development project, tools emphasising technology must be used in balance with tools emphasising human aspects.

The Finnish version of JOT aims at reengineering the company's production operations.

Goal orientation of development

In this approach the starting-point is not the company's overall goal-setting. Instead, the development of production towards the so-called JOT production is an end in itself. The main goals of JOT production are the decrease of current assets and shortening of lead times. As a result, the company will be able to adapt itself flexibly to market demands and the production will become customer-driven.

Systematic identification of development objects

JOT does not analyse the current situation; it is based on an existing solution model, a target state which already exists as a proposal.

Concreteness of development proposals

The development proposals and the order of their implementation are concrete to a high degree. The stages leading to JOT production include the following actions, for instance: short setup times, small batches, layout based on products, mistake proofing, automatic stopping of machines, pull system, levelled production, etc.

Process-basedness

One of the main goals of JOT production is to create and maintain a continuous flow in which the volume of work in progress is small. Continuous-flow production is primary realised by means of a product-oriented layout, and it is constantly maintained by means of production control. The product orientation is also emphasised in the job descriptions of monthly-paid employees. Thus it may be said that the Just On Time approach includes process-based elements.

5.2.6 Manufacturing System Design Decomposition, MSDD

The Production System Design Laboratory (PSD) of the Massachusetts Institute of Technology (MIT), led by Professor Cochran, has developed the Manufacturing System Design Decomposition (MSDD) model for the design and analysis of production systems and the identification of development objects. The model is based on axiomatic design, the purpose of which is to explicate cause-and-effect relationships and to isolate the impact of untoward events from the overall entity. As an example, the summation of several different elements in one single key figure makes it more difficult to understand cause-and-effect relationships.

According to Cochran, MSDD enables the systematic planning of "stable" production systems (Cochran, 1994). In this study the 5.1 version of MSDD is examined. When developing an existing production system with the help of MSDD, the main emphasis lies on stabilisation and corrective improvement.

Goal orientation of development

Since MSDD is based on axiomatic design, it may be regarded as extremely goal-based. The following goals have been set for MSDD (Cochran et al., 2002):

“1. Clearly separate objectives from the means of achievement
2. Relate low-level activities and decisions to high-level goals and requirements
3. Provide a means to understand the interrelationships among the different various elements of a system design
4. Provide a means to effectively communicate information across the organisation”

Systematic identification of development objects

In MSDD, the identification of development objects is based on systematic analyses.

Concreteness of development proposals

The planning framework leads to concrete development proposals which are pre-defined on the basis of goals by means of different cause-and-effect relationships (Design Parameters).

Process-basedness

MSDD focuses mostly on an evaluation of individual operations instead of chains formed by several operations. It may thus be said that MSDD is not process-based.

5.2.7 Six Sigma, SS

Six Sigma starts out from the assumption that focusing on the decreasing of variability will solve the problems of business and processes. The assumption is that a decrease in the variability of individual elements will improve the end result of the overall process.

Six Sigma contains development methods of different degrees. Primarily, the method stresses the decreasing of variability or stabilisation of operation; on the other hand, corrective improvement and optimisation are also stressed. Karjalainen stresses the role of corrective improvement in Six Sigma: "Six Sigma is a method of business improvement which aims to find and eliminate the causes of errors and mistakes in the business process, by focusing attention on outputs which are critically important for the customer." (Karjalainen, 1999). Increasingly, Six Sigma is being implemented together with the Lean philosophy, which increases the importance of optimisation.

It must be noted that Six Sigma can only be introduced by companies of considerable size. The in-house resources of a small company will not be sufficient. Because the application of Six Sigma requires measurement, it was originally utilised in environments with a tradition of measuring and quality control; that is, in the production of physical goods. In applying Six Sigma it must be remembered that if an organisation initiates development because it is capable of doing so (after a strong investment in training), it may find itself developing areas which are not appropriate for business (Nave, 2002).

Goal orientation of development

It may be said that Six Sigma does not examine the general goal-setting of the entity to be developed. The selection of development objects applies the following principles, among others (Harry & Schroeder, 1999): "Quality-improvement projects using Six Sigma are chosen as a result of customer feedback and potential cost savings, not fuzzy notions of continuous improvement. Improvements that have the largest customer impact – and the biggest impact on revenues – are given the highest priority."

Systematic identification of development objects

The method may be considered extremely analytical, The aim is to identify the processes with the largest impact on customer satisfaction. The following step is to identify the variables with the largest impact on product quality, Critical To Quality (CTQ). Finally an assessment is made on how the variables should be affected to reach the desired end result.

Concreteness of development proposals

The stabilising and corrective development actions derived by the use of Six Sigma may be regarded as concrete.

Process-basedness

Customer orientation is emphasised by the CTQs defined by customers, which are used as the basis for defining performance/sigmas. The literature on Six Sigma (e.g., Harry & Schroeder, 1999) emphasises the process-based approach. In American literature on Six Sigma, however, a process is largely understood as a manufacturing process, a chain of work stages.

5.2.8 Supply Chain Operations Reference model, SCOR

The Supply-Chain Council (SCC) is an international, independent non-profit organisation established in 1996, whose membership is open to all companies and organisations interested in developing supply chains. The Supply-Chain Council has developed the Supply Chain Operations Reference (SCOR) model as a standard for the management of supply chains in different branches of industry. With the help of this model the actors in a supply chain are able to understand, compare and develop the supply chains. The aim of the SCOR model is to develop the entire supply chain by developing the operations included in it. The description model helps personnel to understand the functioning of the chain and the role of individuals in it.

The number of companies using the SCOR model in Finland remains relatively low. Most users have applied the model to describing current status and measuring performance level. The users consider that the SCOR facilitates analysis and provides good tools and visualising techniques for describing complicated chains. Learning to use the model is considered a challenging task which requires training. The Finnish companies which have applied the SCOR framework are still at the beginning stages of their SCOR cycle, and the framework has mainly been applied on the processes and sub-processes of individual companies. (Löfgren et al., 2003)

The SCOR framework can be applied in multiple ways for stabilisation, corrective improvement, optimisation and reengineering. In this study the 4.0 version of SCOR is examined.

Goal orientation of development

For the setting of goals the SCOR model offers a number of strategic measuring instruments which enable the setting of primary goals. These key figures measure customer service, the size of tied-up capital and costs. (Löfgren et al., 2003)

Systematic identification of development objects

With the help of the SCOR model, the companies in the supply chain may discuss, measure and assess the chain configuration. Thanks to standardised process vocabulary, measuring instruments, definitions and benchmarking studies will also be easier to formulate and more specific.

The documents of the SCOR model do not describe the analysis method used or guide the implementation of a development project. The model provides information and methods which different organisations can use as they see fit. (Löfgren et al., 2003)

Concreteness of development proposals

For measuring and evaluating processes, the model provides a process-specific list of measuring instruments and eventual "Best Practice" applications. In interviews with Finnish companies within the VALO (*Verkostojen Ajantasainen Logistiikka* in Finnish) programme of the Ministry of Transport and Communications, it was found that external benchmarking data based on the measurements of the SCOR model had not been used (Löfgren et al., 2003). This leads to the conclusion that the concreteness of development proposals in SCOR is moderate.

Process-basedness

The SCOR model covers the entire supply chain from the supplier's supplier to the customer's customer. The model includes interaction with customers and markets and the moves of physical products through the chain. Processes and their descriptions are based on the needs of the manufacturing company and are independent of branch. (Löfgren et al., 2003)

Though the main interest in the SCOR model is focused on the overall supply chain rather than the order–delivery process, the SCOR approach may be regarded as process-based.

5.2.9 Theory of Constraints, TOC

In the 1980s, Eli Goldratt developed the Optimized Production Technology (OPT) to improve production throughput. This served as the basis of a broader approach examining the whole business, Theory of Constraints or TOC (Rahman, 1998). The basis for this broader approach is that in most organisations the constraints are not physical, but linked to management guidelines. TOC starts out from the assumption that each system contains a minimum of one constraint which prevents the system from achieving the higher performance required by its goals. The existence of this constraint creates a potential for improvement. Since the constraint limits system performance, even a small alleviation of the constraint will improve the performance.

Among production activities TOC emphasises the activity which slows down system throughput. TOC is suitable for organisations with a hierarchical structure and centralised expertise (Nave, 2002).

As a mode of development TOC includes elements of stabilisation, corrective improvement and optimisation.

Goal orientation of development

TOC may be considered goal-based, since the method focuses on improving system performance in line with its established goals.

Systematic identification of development objects

TOC provides an approach to continuous improvement, with the main emphasis on an uninterrupted identification and alleviation of constraints. TOC also includes a Thinking Process approach to support decision-making, using cause-and-effect diagrams to identify general-level problems and to develop and implement solutions to them. (Rahman, 1998)

Concreteness of development proposals

In TOC, development proposals focus on the utilisation and elimination of identified constraints. In the case of a physical constraint it must be made as efficient as possible. An administrative constraint should not be made more efficient, but instead eliminated and replaced by a procedure which supports the increased throughput. The other components in the system should be adapted to support the maximal efficiency of the constraint. TOC guides towards the implementation of concrete development actions.

Process-basedness

Within the TOC context, process is understood in a more narrow sense than in this study, i.e., as a manufacturing activity. While TOC focuses on dealing with system constraints, it is not clear whether the system is defined as an operation structure or as a resource structure.

5.2.10 TUOTTO$^+$ programme

The TUOTTO$^+$ programme was developed by the Finnish Ministry of Trade and Industry and a number of partners to support development in SMEs. In the programme an experienced and specially trained consultant reviews the company's key productivity factors. TUOTTO$^+$ is a nationwide, specially formatted service envisaged for the analysis and development of the internal activity of SMEs. It takes into account aspects linked to productivity, quality, environment and safety at work. The analysis is primarily targeted to manufacturing SMEs and companies which provide business services. (Tuotto$^+$, 2002)

The programme implementation emphasises corrective improvement.

Goal orientation of development

The aim of the TUOTTO$^+$ programme is not to identify the most important development objects on the basis of the company's strategic goal-setting. Its purpose is to improve productivity, quality of operation and capability of making profit. Another purpose is to increase personnel involvement in company development and to improve domestic and international competitive ability.

Systematic identification of development objects

The operational areas to be analysed include *products and markets*, *management and personnel*, *company resources and operational framework* and *company productivity*. TUOTTO$^+$ includes the following formal analyses:

- financial key figures,
- personnel questionnaire,
- interviews with key persons and
- Tuotto observation.

The commercialised Tuotto observation is used for examining the operational framework. In itself, the use of the analyses in drafting the development plan relies on the expertise and experience of the consultant who carries out the analysis.

Concreteness of development proposals

The TUOTTO$^+$ programme includes a proposal for a development and action plan, based on the analyses carried out. The programme itself does not guide towards concrete development actions or propose development options. The material generated is more in the nature of a checklist of issues of general importance.

Process-basedness

The heading of one of the sections in the analysis focuses attention on the flow of the order–delivery chain (overall control). The analysis has no other links with the process-based approach.

5.2.11 Value Stream Mapping, VSM

Value Stream Mapping is a concrete part of implementing the broader Lean Thinking philosophy. The approach is included here because it may be used to identify the development actions needed.

The method documents the product's production path from the customer to the supplier and creates a meticulous description of all material and information flows. After this, a set of questions is asked and a description made of the future value flow.

When using VSM, a reengineering of the operating mode will be considered if there is a considerable difference between the current and ideal states.

Goal orientation of development

The description begins with customer requirements (linked to the manner of delivery of the product). As Lean Thinking has observed, the start of any development action is preceded by an unambiguous definition of product value for the end customer (Hines & Taylor, 2000).

The method aims at an ideal state as an end in itself: Products are made as a completely continuous flow, short throughput times enable production on the basis of confirmed customer orders alone, without setup times between products.

The method cannot be considered particularly goal-based in the sense of this study, except for the fact that the product value is defined by the end customer.

Systematic identification of development objects

Value Stream Mapping is a qualitative tool for a detailed description of how a factory should operate to create value (Rother et al., 1999). The method stresses the importance of identifying wasteful procedures. This, however, remains basically on the level of a statement: the wasteful procedures identified are not analysed in more detail, there is no attempt to make different forms of waste commensurable or to weight them in comparison to each other.

Concreteness of development proposals

The plans for reaching the target state strive to eliminate the basic causes of waste in the value flow. The implementation of the future value flow is based on a vision. Mapping helps to see and focus the flow with the help of the ideal, or at least an improved, vision.

The aim is to build a production chain in which the individual processes are linked to their customers through either continuous flow or pull. As closely as possible, every process only produces what the customer wants **and** when he wants it.

The method proposes concrete development actions, its own "patent solution". What is "right" for the value flow description gives the right to rapidly eliminate the basic causes of waste. Because of this, the mapping techniques should be treated as a provocative proposal (Rother et al., 1999).

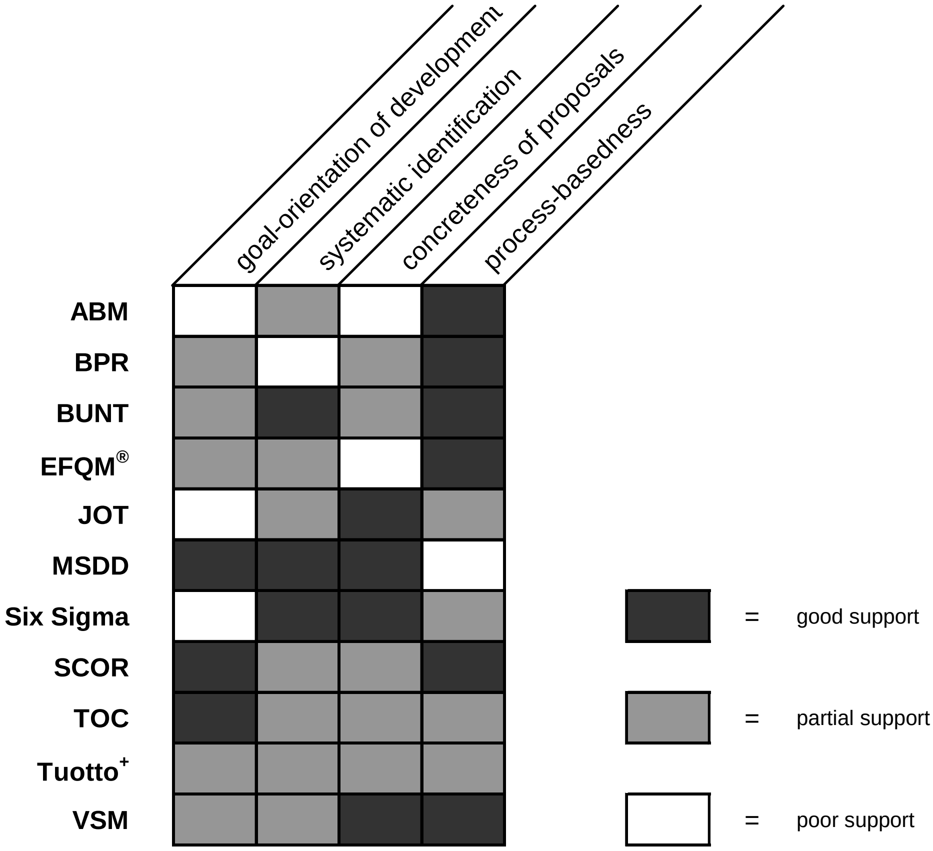
Process-basedness

The method may be considered process-based, because it focuses on floor-level, door-to-door material and information flows.

5.3 Summary

Table 5.1 presents a summary of assessments of the characteristics of the development methods reviewed here.

Table 5.1 Summary of the characteristics of the development methods reviewed.



5.4 Need for research

The summary presented in Table 5.1 shows that none of the methods of identifying development objects examined above meets all the requirements for such methods expressed in this study. Therefore, there exists a clear need for developing an identification method which would meet all the criteria presented.

PART III:

MODEL DEVELOPED

6 DEVELOPED MODEL ON A GENERAL LEVEL

This chapter presents the summary and the framework of the model developed in this study to optimise the performance of the order–delivery process.

According to the development cycle described under 4.3.1, the development actions of different levels, *stabilisation, improvement* and *re-engineering*, follow each other within a certain period of time. The starting-point of the method for identifying development objects presented in this study is the improvement of the existing order–delivery process by optimisation.

Prior to optimisation, the stability of the process must be ensured, an overview of process performance must be gained and the adequacy, against the goals given, of performance improvement accessible by optimisation must be ensured.

The Activity-Based Optimisation (ABO) model developed here basically follows the same order regardless of which operational success factor is selected: whether operational quality, resource costs or speed is optimised. Since the immediate development object when optimising the management of resource costs is resources, the succession presented here must be modified for that case.

The stages preceding the optimisation of the order-delivery process are presented in Figure 6.1 (stages 1-5):

- define the objectives,
- model process,
- stabilise process,
- measure performance,
- determine level of development and
- optimise performance according to selected operational success factor.

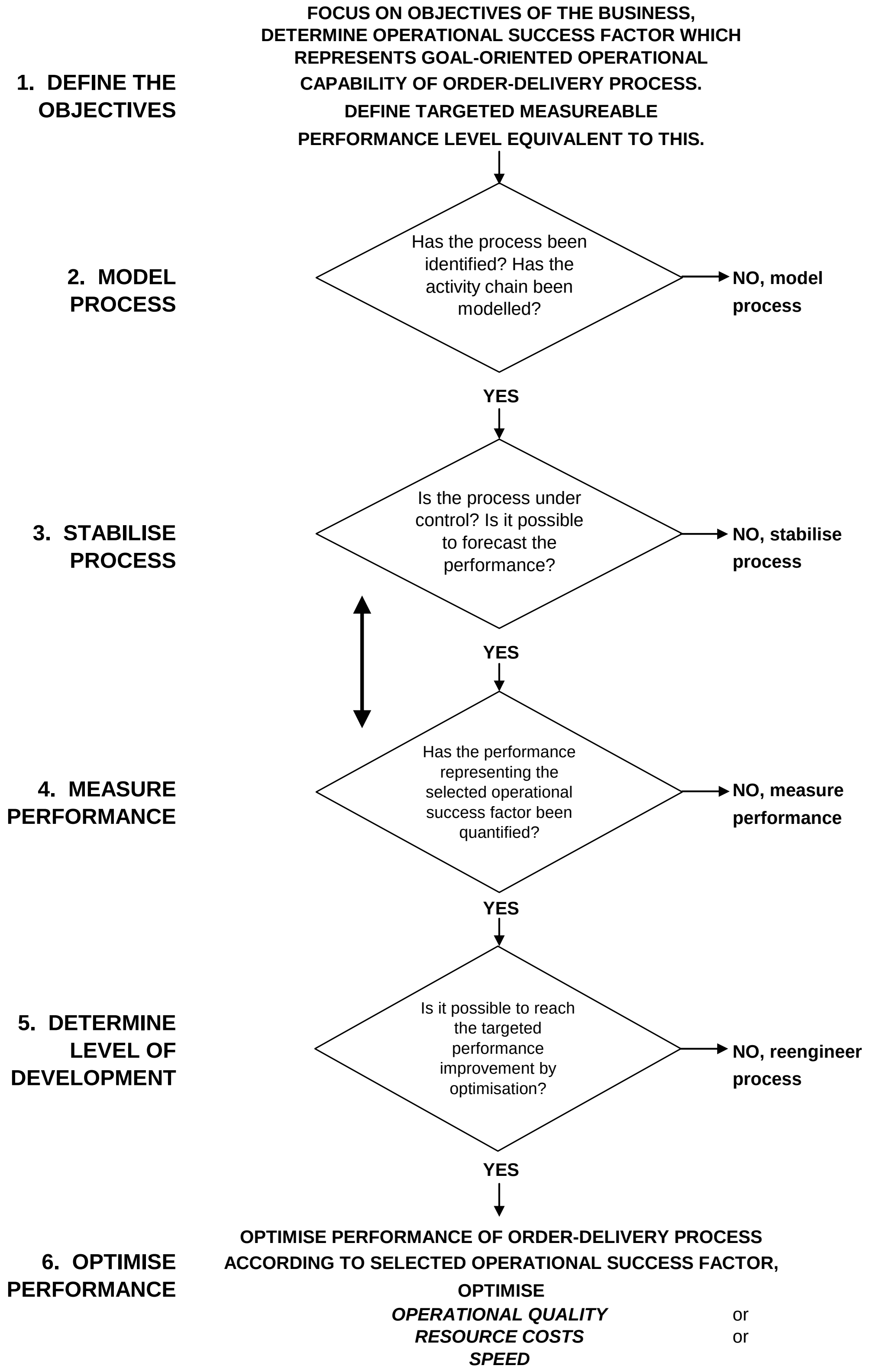


Figure 6.1 Stages preceding ABO.

Although the analyses used in identifying development objects are presented as clearly quantitative, some of them should actually be regarded more as qualitative in nature. Since all key figures needed for the analyses cannot always be determined with the precision given, the key figures to be used will have to be evaluated by qualitative criteria. However, this should by no means detract from the value of the analyses as a support to decision-making. The approach contains obvious links to the applications of Activity-Based Costing (ABC). Costs determined by ABC cannot always be regarded as absolutely exact. What is essential in ABC applications, however, is that they provide significantly more correct cost data than before, to support decision-making.

The following chapters discuss the components of the above figure in more detail.

6.1 Define the objectives

Content of the stage:

Define the company's business areas and their business ideas. Select the operational success factor which describes the goal-oriented operational capability of the order–delivery process. Select the key figure to measure the performance of the operational success factor consistent with goals and determine a target value for it.

Goal of the stage:

Identify, as a starting-point of development, the operational success factor of the order–delivery process consistent with the goals and the corresponding performance level.

Although the model developed in this study attempts to optimise the order–delivery process inside the value net, business ideas are traditionally defined primarily to describe the strategic choices of individual companies. The operational success factor of the order–delivery process depends on the business idea of the company which owns the order–delivery process in the value net.

The content of the business idea is described in more detail in Chapter 3. Paragraph 3.2.4 lists the key figures used in this study which correspond to the operational success factors presented.

In selecting the key figures and their target values, their interactions and the risk for partial optimisation must be understood. As an example, the optimisation of resource costs stresses the improvement of utilisation rates. On the other hand, high utilisation rates are not necessarily optimal for a controlled and rapid throughput.

The definition of objectives has been discussed in more detail in chapter 3.

6.2 Model the process

Content of the stage:

Draw up an understandable and manageable activity net description of the order–delivery process studied.

Goal of the stage:

Identify the operations included in the order–delivery process and the connections between them.

Stages 2–4 as presented in Figure 6.1 stabilise the process and its performance. During these stages the process maturity is brought to a level where the process performance is controlled and measurable and where performance improvement may be initiated.

During stage 2, the order–delivery process is modelled as a chain or net of activities.

Process modelling has been discussed in more detail in chapter 2.5.

6.3 Stabilise the process

Content of the stage:

Stabilise the order–delivery process to be improved.

Goal of the stage:

Bring the order–delivery process under control in such a way that its performance can be predicted.

At the beginning of the development project, the stability of operations should be ensured. Stabilisation of operations requires that the operation occurs repeatedly and is in the nature of a continuous process. The improvement of activity performance requires that the variability in the activities is reduced, the operation is stabilised, because:

- the different activities in a chain are interdependent; variability in one activity causes variability in all successive activities,
- variability in, e.g., throughput, will almost invariably only accumulate negatively; in other words, accumulation of slowdown will occur (Goldratt & Cox, 1987),
- if variability is great, the performance of an activity cannot be determined.

Only when an operation is sufficiently stable will it be possible to assess the true performance of operation and the consequent development potential. A reduction of variability will in itself improve the average performance of the process. Processes are primarily stabilised by identifying and eliminating special causes of variability.

Stabilisation will be discussed in more detail in Chapter 7.

6.4 Measure performance

Content of the stage:

Measure the performance level of the order–delivery process and the activities included in the corresponding activity net in terms of the operational success factor selected.

Goal of the stage:

Identify the potential performance of the order–delivery process and the activities included in the corresponding activity net.

Paragraph 3.2.4 listed the key figures of performance which are linked with operational success factors. At this stage at the latest, the corresponding measurement of performance must be started. As was pointed out under the previous heading, the performance of an activity cannot be assessed unless it is stabilised.

In this study, only average values are used in the context of performance measurement. The use of averages involves the obvious risk of overlooking operational variability. The starting-point in this study is to stabilise the operation studied so as to reduce its variability and to make the corresponding performance predictable.

Performance development will be discussed in more detail in chapters 8, 9 and 10.

6.5 Determine level of development

Content of the stage:

Assess separately the development potential included in each activity. Determine the development potential of the order–delivery process on the basis of the potentials of activities included in the process. Assess the adequacy of the total development potential against the targets set. Select an appropriate level of development.

Goal of the stage:

Select an appropriate level of development.

An optimal performance level is set for each activity by means of *benchmarking*. This term is used for a model developed in the Rank Xerox group, in which operational development makes use of more advanced organisations by comparing their performance to the organisation being developed (Venetucci, 1992). Benchmarking may be divided into two parts. The aim of the strategic approach is to revise strategic planning after the company has become aware of its relative strengths and weaknesses. In this context benchmarking may be carried out against a similar operation in a different branch or against the best achievable practice in the same branch. Benchmarking must ensure that the two entities compared correspond to each other as to content.

The actual performance of each activity is compared to a defined optimal performance, and the development potential of each activity is determined. The development potential of the whole process is determined as the total of the development potentials of the activities included in it.

On the basis of the development potential achievable by optimisation, the appropriate level of development is selected: will evolution (improvement) be enough, or will revolution (reengineering) be needed? If the development potential achievable by optimisation is found to be insufficient in comparison to the targets set, it is necessary to examine the product range and product characteristics offered and/or start a reengineering of the process or of a more comprehensive operation structure. When starting reengineering projects it must be remembered, as pointed out under 5.2.2, that the practical implementation of process reengineering will not be possible without strong leadership.

The determination of development level will be discussed in more detail in chapters 8, 9 and 10.

6.6 Optimise performance

Content of the stage:

Optimise the performance of activities with the greatest development potential.

Goal of the stage:

Achieve the optimal performance of the order–delivery process.

6.6.1 Select activities for development

There are numerous methods for prioritising development objects. An example of this is the Pareto Priority Index (PPI) for the evaluation of development projects, presented by Hartman (Gryna, 1988):

$$PPI = \frac{\text{savings x probability of success}}{\text{cost x time to completion (years)}} \quad (5)$$

A high PPI score recommends a high development priority.

In his dissertation on productivity and Activity-Based Costing, Rantanen (1995) presents the Urgency Analysis method for classifying production activities on the basis of three characteristics: worth, possibility and necessity. The measures awarding greatest savings or increases of income will receive the highest *worth to improve* value (W). Similarly, measures which are assumed to contain the greatest potential for improvement will receive the highest *possibility to improve* value (P). Measures with the most urgent need for improvement will receive the highest *necessity to improve* value (N). The *Urgency Points* (UP) of each activity may be calculated as follows:

$$UP = a \times W + b \times P + c \times N \quad (6)$$

The weighting factors (a, b, c) may vary according to situation, purpose, values, etc. After calculating the scores, the activities are divided into three priority classes (A, B, C) on the basis of their scores. The number of activities to be allocated in each class depends on the circumstances of the decision.

The prioritising of issues and solutions included in BUNT includes the following steps (The European Handbook of Management Consultancy 1995, p.197):

- identifying and evaluating the prioritisation criteria of issues,
- assigning priorities to issues according to the criteria selected,
- identifying and evaluating the prioritisation criteria of solutions,
- selecting key solutions for each issue and
- prioritisation of solutions selected.

Table 6.1 Prioritisation matrix used in BUNT (The European Handbook of Management Consultancy 1995, p.197).

Company: Topic:											Date: Page:
Importance (5-1)	5	4	3	5	4	2	4	5			
Prioritising Criteria / Issue	Increases Revenue	Reduces Costs	Removes Bottlenecks	Means Comp. Advanatage	Profiles the Company	Better Work Enviroment	Increases Competence	Simple/ Quick Implement	Numerical Result	Intuitively Correct	Result
1. Can a reorganising of jobs lead to saving in production, and between administration?	-	3	-	2	2	4	3	5	3.1	5	5
2. An "experience database" containing technical information on earlier projects would contribute to increased quality. How should such a "database" be implemented?	-	5	5	5	4	2	4	3	4.1	5	5
3. An "experience database" ….	-	5	5	5	4	2	4	3	4.1	5	5

In this study, the activities to be developed are identified in a two-step analysis:

1. Importance of activity

All activities included in an order–delivery process are not of equal importance for the overall process performance. In assessing the importance of activities, their quantitative contribution to performance according to the operational success factor will be determined.

2. Development potential of activity

The development potential of each activity is determined as the difference between optimal and actual performance.

A simultaneous examination of the importance and development potential of individual activities, as presented in Figure 6.2, reveals the activities which should primarily be developed.

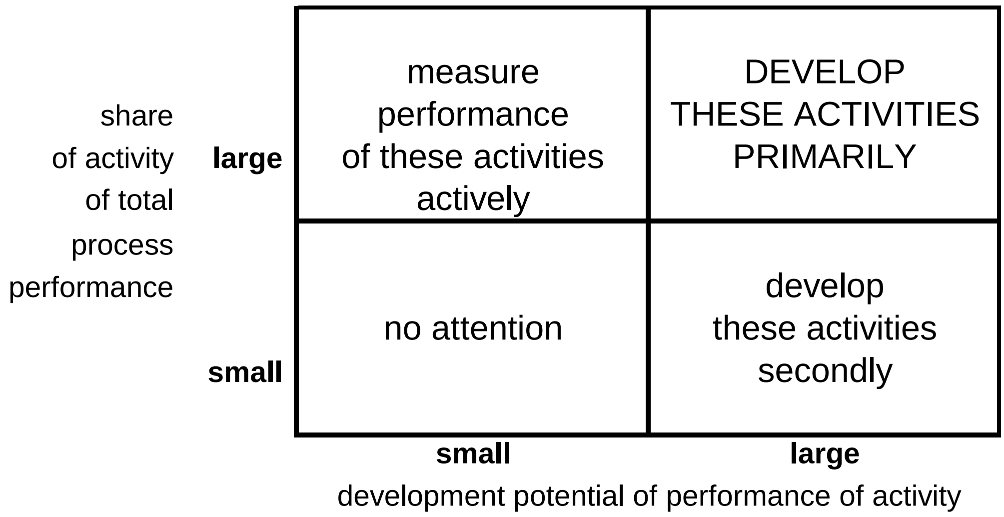


Figure 6.2 Selection of activities to be developed.

In the following chapters the developed model is explained in more detail. Chapter 7 defines measures used in stabilisation. Chapters 8, 9 and 10 define measures used in development, corresponding to the selection of operational success factor.

6.6.2 Identify factors detrimental to the performance of an activity

After the selection of activities to be developed, the factors which weaken the performance of these activities should be identified. Each activity is assessed using the following factors:

- identification of waste,
- uniformity of products and operations and optimality of operations,
- uniformity of operations and resources and optimality of resources,
- uniformity of product architecture and operation and resource structures,
- (optimisation of methods implemented in an operation) and
- (revision of lower-level operations included in the activity).

Chapters 8, 9 and 10 introduce similar measures for each operational success factor.

Implementing the development actions

Chapters 8, 9 and 10 present development actions for improving the performance of activities depending on the operational success factor.

7 STABILISATION

This chapter deals with the stability of the order–delivery process and presents, in the nature of an example, a method for identifying the factors detrimental to stability and various measures to stabilise the process. The aim of stabilisation is to bring process maturity to level *4 – Managed*.

All operations contain variability. Before the performance of a process can be assessed and improved, its inherent variability must be brought under control. The primary task is to eliminate variability due to special causes.

The growing demand for flexibility poses particular demands on the stabilisation of operation. If a process cannot be stabilised, the first stage will be to assess the unambiguity of the goals set for the process, or the degree of flexibility desired. If there are marked differences between the various needs which the process is designed to meet, its stabilisation will increase correspondingly in difficulty.

7.1 Goals of process

The content of the business idea was discussed in Chapter 3. The business idea is used by the company to define the factors which it relies on to serve its customers and to compete in the market. Before a more detailed analysis of process stability, it is useful to examine the goals of the process:

- Are the process goals consistent with the business idea?
- Are the process goals unambiguous?

If the goal-setting of the entire process is vague, this will naturally also be reflected in individual activities. If the company's business idea itself is not clearly unambiguous, the goal-setting of the order–delivery process cannot be unambiguous either, nor can it consistently work towards the higher-level goals.

7.2 Product and process adaptabilities

The conformity of products and process may be assessed by means of several factors. Since adaptability is a fundamental factor with multiple effects, it is selected for special examination here. Before more thoroughgoing activity-based analyses, the adaptability of the order–delivery process should be compared with product adaptability.

An analysis of product adaptability:

- How is product adaptability defined in the business idea?
- What is offered to the customer in practice, what is the adaptability of the products made?
- If the actual product adaptabilities do not correspond to the definition in the business idea, new definitions to correspond to actual products are written (e.g., A, B and C products).
- The orders completed are analysed over a suitable period of time against the above analyses (example: last year's deliveries included 70 % of A products, 20 % of B products and 10 % of C products).

An analysis of process adaptability:

- Which of the products (A, B or C) as defined above does the process operation typically correspond to?
- Can alternative modes of operation be identified in the order–delivery process?
- Define the alternative modes of operation in more detail (e.g., processes A, B and C).

An analysis of the correspondence between product and process adaptabilities:

- To what extent do the product and process adaptabilities correspond to each other? Table 7.1 shows a case in which the order–delivery process includes processes A and B, corresponding to products A and B.

Table 7.1 Correspondence between product and process adaptabilities.

		Process A	Process B	DIFFERENCE
70 %	Product A	70 %		
20 %	Product B		20 %	
10 %	Product C			10 %

Table 7.1 shows that the correspondence between product and order–delivery process adaptabilities is 90%.

If the company's business idea is not geared to offering products customised to customers, but in practice this is seen to happen, the situation must be examined from the point of view of strategic planning.

Process C, involving plenty of decisions, is capable of producing standardised products A, but is unnecessarily cumbersome for this, since it involves many operations not needed for products A. If the standard process A is forced to produce customised products C, the process will invariably be disturbed. A difference of, say, 10% between product and process adaptabilities should not be ignored, as in this case it is extremely likely that the well-known Pareto's 80/20 "rule of thumb" becomes operative: 80% of the control operations needed will be caused by 20% of products for which there is no operating mode with a corresponding adaptability.

In line with its objectives, this study develops a method which allows the identification of development objects to optimise the order–delivery process, with the product regarded as given. Naturally, practical development efforts also attempt to modify the product by such means as standardisation and modularisation.

Product standardisation may reduce the variability in product specifications and the need for product flexibility in production. Systematic product design may help to make the products as production-friendly as possible. For a new product, production-friendliness means that the product conforms with the dominant operations and resources and corresponding structures. If the product and its variations are correctly designed, there is no need to make a new and different product because of small changes in customer needs.

A modular product architecture may be considered ideal, as it can be used to define a broad range of product variations with the same architecture. Modularity contributes to a stable product architecture and also enables a stable operation structure. The number of interfaces between operations in a stable operation structure may be minimised. This means that activities and processes correspond to the modules. If the product architecture is not modular and varies from one product to another, it is impossible to form a corresponding operation structure which is stable. Case-specific products, which have no stable product architecture, are realised in projects with case-specific operations and corresponding operation structures.

If product and process adaptabilities are in obvious conflict and the multiple demands on the product may be regarded as compatible with the vision defined by strategic planning, companies must have the courage to design a new operating mode to correspond to the products on offer.

7.3 Process maturity level

The identification of process maturity level helps in determining process stabilisation. On the basis of the definitions presented it may be said that on maturity levels 1–3, process operation is not stable. The identification of process maturity level does not require in-depth quantitative analyses; qualitative assessments based on interviews with key persons could well be sufficient for an adequate result.

7.4 Selection of activities to be developed

In this context the stability of individual activities is assessed on the basis of the probability of their realisation. How well is the realisation of the activity managed, what is its predictability? In this study, the indicator *reliability of delivery* is used as both an internal and an external measure. As an external indicator linked to a competitive factor, reliability of delivery shows the probability of the realisation of the delivery time promised to the customer. As an internal indicator linked to a success factor, reliability of delivery describes the probability of the realisation of the standard lead time for the operation studied.

When needed, reliability of delivery can be divided into two factors:

$$\textit{Reliability of delivery} = \textit{reliability of delivery (gross)} \times \textit{capability of producing quality} \quad (7)$$

Reliability of delivery (gross) measures the predictability with which the gross quantity of the desired products can be realised in a defined throughput time.

The predictability with which the products meet the quality criteria set is measured by an operation's *capability of producing quality*.

$$\textit{Capability of producing quality} = \frac{\textit{number of realised products - number of disqualified products}}{\textit{number of realised products}} \quad (8)$$

Naturally, the measuring of activity-specific reliability of delivery requires that standard lead times have been defined for each activity. Table 7.2 presents an example of the reliabilities of delivery specified for activities included in the critical path of the order–delivery process.

Instead of reliability of delivery, an alternative object of measurement could be the probability of realisation of work volumes or costs assessed for each activity.

Table 7.2 Reliability of delivery of individual activities.

ACTIVITY	reliability of delivery
order processing	95 %
material management	90 %
purchasing	80 %
production management	95 %
part manufacturing	54 %
assembly	80 %
delivery	80 %
Reliability of delivery of order-delivery process	**80 %**

In practice, the reliability of delivery of the final activity in the order–delivery process (= the reliability of the entire process) may be better than those of preceding activities. This is typical for processes at low levels of maturity, where operations have not been stabilised and optimised. In such cases, different types of buffers contained in the operation structure will diminish the impact of poor work conditions and, on the other hand, outstanding individual performance will help to offset the impact of disturbances.

The primary development object should be the activity with the lowest reliability of delivery. If the causes of the poor reliability are attributable to preceding activities, the analyses carried out during the subsequent stages of development will guide attention to these activities.

7.5 Identification of factors detrimental to the stability of activity

In this context, the stability of the activity selected for examination is assessed according to the probabilities linked to its elements, or the *predictability* of elements, as presented in Table 7.3. Despite the quantitative manner of presentation, the analysis should rather be regarded as qualitative. The essential point is that all factors with an effect on the reliability of delivery will be assessed as being of equal value. The table is explained in more detail later in this chapter.

Table 7.3 Elements of the reliability of delivery of an activity.

ELEMENT	predictability of elements
unambiguity of goals	98 %
conformity of adaptabilities	90 %
realiability of delivery of INPUT products	85 %
usefulness of current assets	91 %
availability of fixed assets	95 %
presence of personnel	92 %
internal reliability of delivery	95 %
internal capability of producing quality	95 %
reliability of delivery of an activity	**54 %**

The reliability of delivery of individual activities in Table 7.3 is defined as the result of the predictabilities of each element. If liquid assets are a significant resource for the activity, they should be included in the examination as a separate item. In this context, the resources which affect the reliability of delivery of an activity are treated as equal, with no account taken of how critical the resource is for throughput. In other words, only availability is examined in this context, without taking account of the utilisation rate.

In practice, with processes of low maturity, the reliability of delivery of individual activities may be better than that calculated from its elements. There are several reasons for this: the efficiency/lead time of the activity has not been optimised, the utilisation rates of the main resources are not optimal, the time buffers included in the activity allow faster performance in special cases.

7.5.1 Unambiguity of goals

An assessment of the unambiguity of the goals set for the activity should not be overlooked. For the improvement of stability of operations, the unambiguity and standard format of information products is of great importance, as such products define the goals of the operation: the products realised in the operation, its links with other operations, the resources consumed by it, the corresponding resource structures and the operational performance targets.

In practice, it may be difficult to assess the unambiguity of the goals set for activities. The assessment may be qualitative rather than quantitative. However, a qualitative assessment should also, as far as possible, be converted to a percentage (0–100 %). The percentage 100 % means that the goals set for the operation are completely unambiguous in relation to factors such as the prioritisation of operational success factors, for example.

7.5.2 Conformity of product and activity adaptabilities

The correspondences between product and activity adaptabilities are assessed separately for each activity in the same ways as was done under 7.2 for the adaptabilities of products and the order–delivery process. The assessment is qualitative as well as quantitative. At this stage, however, it is essential to examine this issue as one of the factors affecting the stability of activity.

7.5.3 Reliability of delivery of INPUT products

The primary focus of examination is the overall effect of the reliability of delivery of all INPUT products of the activity (= the result of the reliabilities of delivery of all INPUTs). If there are significant differences between the reliabilities of delivery of different INPUT products, they may have to be divided into groups which behave homogeneously from the viewpoint of the examination.

On the basis of the author's experience it is easy to underrate the significance of individual INPUT products for the whole. The basic truths of the theory of probability tend often to be forgotten. Let us assume a situation in which an activity processes seven INPUT products, each with a reliability of delivery of 90 %. Thus, the probability of the availability of all the INPUT products as planned is

$$90\,\%^{7} \sim 48\,\%$$

Although, in terms of conditions prevalent in Finland, the starting-point is good (few INPUT products, adequate reliability of delivery), even in this case the likelihood of not all INPUT products being available as planned is greater than that of all of them being available.

7.5.4 Usefulness of current assets as a resource

The usefulness of current assets may be used to assess the management of current assets. The examination concerns the effect of wastage, inventory losses, spoiling, etc. on the operating conditions of the operation in question.

$$\textit{Usefulness of current assets} = \frac{\textit{annual purchases - annual losses}}{\textit{annual purchases}} \qquad (9)$$

The usefulness of current assets measures the probability with which an INPUT product acquired (for storage) will be available to the operation which needs it.

7.5.5 Availability of fixed assets

As regards machinery, *availability* as an indicator shows the proportion of planned working hours during which the resource may be used:

$$\textit{Availability} = \frac{\textit{planned working hours - down time}}{\textit{planned working hours}} \qquad (10)$$

Availability is used to measure the probability of availability of fixed assets as a resource. In this context the primary focus of examination is the combined effect of the availabilities of all fixed-asset resources for the activity. If there are significant differences between the availabilities of various machines and equipment, the fixed assets may need to be divided into groups which behave homogeneously in terms of examination.

7.5.6 Presence of personnel

In this study, the *percentage of personnel presence* is used to measure the probability of availability of the personnel as a basic resource.

$$\textit{Presence of personnel (\%)} = 100\ \% - \%\ \textit{of absences} \qquad (11)$$

Absences include all absences which have an effect on the planned working hours.

7.5.7 Internal reliability of delivery of an activity

In this study, the *internal reliability of delivery of an activity* is used to measure the inherent reliability of delivery of the operations included in the activity, excluding the effect of external factors. This is assessed in gross terms, including all products which are generated. The internal reliability of delivery of an activity is affected, among other things, by the correspondence between products and the methods used in the activities and the resources consumed and the corresponding product architectures and operation and resource structures. If the internal reliability of delivery of an activity cannot be analysed appropriately, it may be ignored at the initial stages of analysis, i.e., its value may be set at 100 %. Once the disturbances due to causes external to the activity have been minimised, there are better opportunities for assessing the internal reliability of delivery and for identifying internal causes of disturbance in the operation.

7.5.8 Internal capability of producing quality of an activity

In the context of assessing the internal capability of producing quality of an activity, the proportionate share of qualified products out of all products generated will be estimated.

7.6 Stabilisation of activity

In practice, Finnish metal workshop businesses mainly attempt to solve the problems emerging in the order–delivery processes immediately, without a more detailed analysis of the underlying causes. This procedure is supported by the practice that the Finnish workplace culture still often places a high value on heroic, one-off personal efforts typical of processes with a low level of maturity.

7.6.1 Improving the unambiguity of goals

The goals set for an activity should primarily be evaluated on the basis of higher-level goals: are the goals set for an individual activity consistent with the goals set for the whole process?

The goals set for an activity should provide an unambiguous answer to the basic questions derived from the business idea:

What products and for whom does the activity produce?
What is the goal-oriented mode of operating of the activity?
What performance goals have been set for it?

7.6.2 Improving the conformity of product and activity adaptabilities

If the adaptabilities of the products achieved by the activity and the activity itself do not conform to each other and it may be seen that the products do conform with the business idea, the internal operations of the activity and/or the operation structure need to be modified.

7.6.3 Reducing variability in INPUT products

In INPUT products, variability may occur in all three competitive factors: product quality, price and delivery time. In this context attention is focused on reducing variability due to delivery time, that is, on improving the reliability of delivery of INPUT products, and on the homogeneous quality of INPUT products.

7.6.3.1 Improving the reliability of delivery of INPUT products

The starting-point for improving the reliability of delivery of internal and external suppliers is monitoring and feedback. In many cases the matter has been solved by having the supplier itself monitor its reliability in an agreed manner and report on it to the customer. Classifying the causes of delays and compiling statistics according to the principles of continuous improvement will help to identify the root causes of variability in operations.

If continuous improvement is not in line with the current practice and business climate, it is possible to study the conditions of working with the help of a separate survey of disturbances in the context of development projects. Such a survey may be implemented as a continuous time management study, during which the researcher classifies the disturbances occurring, according to an agreed classification.

Let us take the example of *assembly*. The controlled performance of this activity requires that all basic INPUT products shown in Figure 7.1 are available simultaneously and meet the agreed quality.

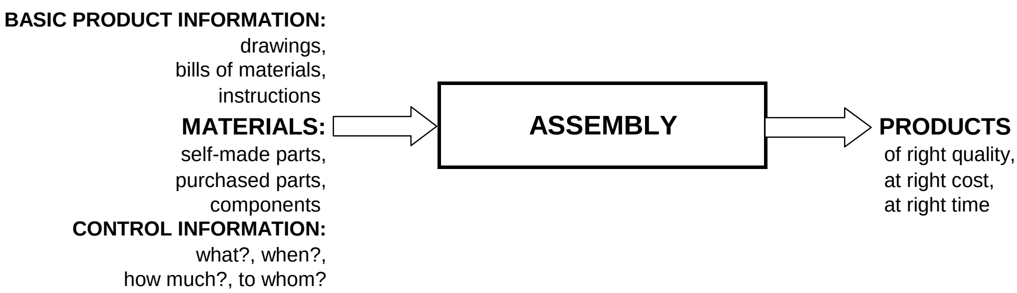


Figure 7.1 Basic INPUT products of assembly.

Disturbances noted in assembly may be categorised on the basis of whether the disturbance was due to the timing or poor quality of the INPUT product, or on the basis of whether the disturbance was caused by internal or external causes. Some causes of poor management of assembly are shown in the cause-and-effect diagram in Figure 7.2.

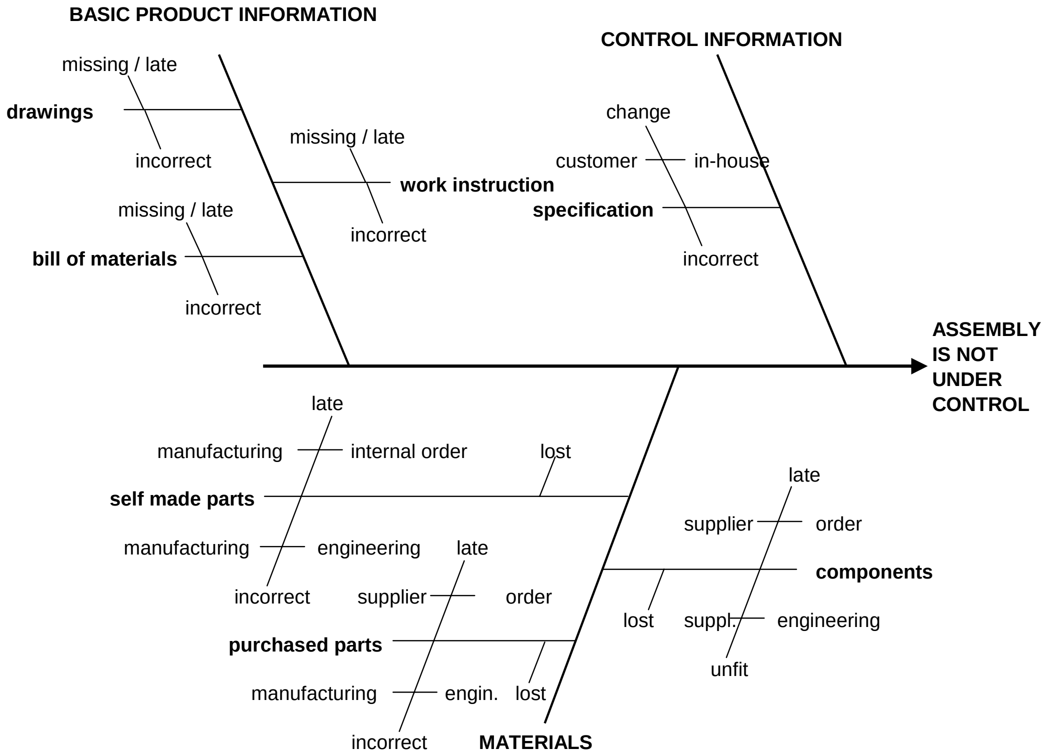


Figure 7.2 Causes affecting the poor management of assembly.

The causes of disturbance together with the time of occurrence can be recorded during a survey of disturbances. The observations recorded enable a Pareto analysis of the causes of disturbance in assembly. The analysis helps to identify the primary causes and leads to a proper focusing of development actions.

Alternative scheduling principles

The vulnerability of operation caused by delayed deliveries can be affected by buffer inventories and similar time buffers. If the materials and parts required by an activity are purchased with the help of requirements planning, and the deliveries of items are scheduled according to the principle of *reverse scheduling*, all items purchased will have a critical path of their own. The delayed delivery of even a single item will prevent the work from being started as planned. One of the ways of amending this situation is as follows (Figure 7.3):

A Add time buffers on a case-by-case basis to items other than the one which determined the critical path.

B Modify the scheduling principle, start the deliveries of all items simultaneously with the one which has the longest delivery time. This creates a time buffer for all items except the one with the longest delivery time. The buffer inventory thus created will naturally increase the volume of current assets to some extent.

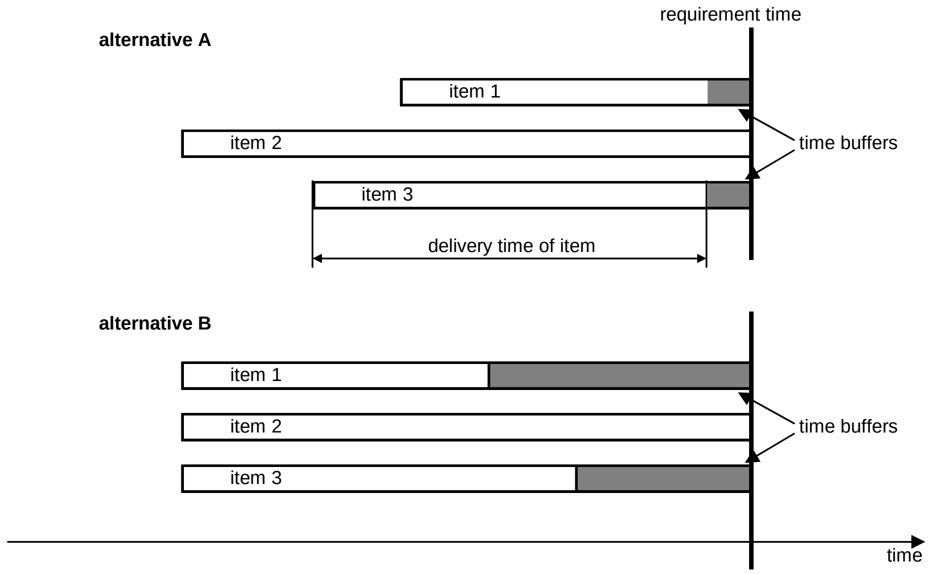


Figure 7.3 Alternative principles of scheduling.

Reliability of delivery of individual suppliers

The unambiguous measuring of the reliability of delivery of a supplier requires that the rules of co-operation are detailed enough. This means that the company needs also to look at its own activity:

- How often does the company itself modify the content, quantity or scheduling of an order, or the product ordered?
- What are the delivery times specified for this supplier?
- Are the delivery times applied appropriate and realistic for both parties?
- Have the best possible conditions been ensured for the supplier's operations?
- Can the customer modify its own procedures so that the supplier could receive an impulse at the earliest stage possible?
- Is the supplier given the kind of service that the company itself would like to get?

Co-operation and updating of the information accessible to suppliers may be supported by means of IT and shared information systems. True partnership and the matching of procedures begins with the mutual understanding and acceptance of needs and capabilities. Too often, the subcontractors as supplier is forced to solve an equation which has been too much for the main contractor, simultaneously attempting to maximise good delivery capability and high availability of capacity.

7.6.3.2 Stabilising the quality of INPUT products

The purpose of quality checks on INPUT products prior to the activity aims at eliminating disturbances due to external causes and creating the conditions for stabilising the activity without external disturbances. The checks can alleviate symptoms but not remove actual problems. Checks carried out on materials, components and controlling material prior to the activity should be regarded primarily as firefighting, not so much as a permanent procedure. The homogeneous quality of INPUT products should primarily be ensured by the operations which generate them.

Stabilising the quality of physical products

The measures to improve the capability of producing quality of an activity are discussed in more detail under 7.6.8.

Stabilising the quality of information products

As regards information products, the stabilising of quality means the improvement of unambiguity of information. Because variability in information at the beginning of the process will cause variability along the whole process, upstream activities must be aware of their responsibility in steering the entire process.

Forecasts

Attitudes towards variability in forecasts used in the planning of an activity are twofold. Forecasting practices must be improved, variability in forecasts must be reduced, but on the other hand the dependence of the activity on forecasts must be decreased by improving its sensitivity through shortening lead times. As an example, the quality of sales forecasts may be stabilised by stressing the importance of a fixed format and presentation of the forecast data.

Product information

The product information defining the basic product is a crucial INPUT product in the order–delivery process. The management of the order–delivery process depends strongly on the stability of this product information. Product specifications are an essential element of a broader entity, product management. As regards this, the following general statement applies:

"Process management requires product management"

It is not always necessary that the *product process* attempts to define all product information down to the same degree of detail. At times it may be appropriate to leave some of the case-specific decisions to be made during the order–delivery process. By defining several sets of specifications it is possible to focus the product planning resources, which are always limited, to what is important. Product information may be classified in the following ways:

A Planning specifies the complete construction, which is only realised according to specification. If the specification (e.g., a drawing) is not unambiguous, the ambiguity must always be gone over with Planning.

B Specification of principles, in the form of, e.g., factory standards or instructions on work procedure.

C No unambiguous specification (e.g., photograph); the realising unit is given a comparatively free hand.

The arrangement presented here will broaden the demands placed on product information and is likely to shorten the production time of product information and to improve reliability of delivery. If the corresponding decisions have been correctly made, the overall efficiency of the product and order–delivery processes can be improved.

Customer order

A customer order which has been forwarded as incomplete cannot be processed in standard ways and throughput times. The products of the activities *Offer* and *Order processing*, i.e., offers and the subsequent customer orders, may be standardised by the use of various forms and IT solutions. IT solutions (such as sales configurators) mostly include sets of rules to prevent the forwarding of faulty or deficient order information downstream in the process. The customer order must unambiguously define such things as the manner and terms of delivery, within the rules agreed on in the company.

Stabilising the quality of services

Variability can be managed better if the object studied is divided into several quality categories on the basis of the degree of variability. Numerous national and international standards based on categorisation are used in industry, as well as tolerances derived from them. The stability of the manufacturing services provided by sub-contractors may be assessed by categorising the sub-contractors.

The following is a categorisation of sub-contractors by a company:

A The sub-contractor has a certificate based on ISO 9001 awarded by a third party.

B The sub-contractor is of long standing and has a documented quality system which is adhered to, or the sub-contractor has issued a commitment to quality assurance.

C The sub-contractor is of long standing or is otherwise well known. No essential deficiencies have been noted, and the sub-contractor has shown a willingness to improve its operation.

D New sub-contractor, subject to evaluation.

E Sub-contractor whose operation is not acceptable and which should thus not be used. In urgencies, use is allowed only when authorised by the quality manager and when the causes leading to the decision and the responsibilities related to the use are documented.

The categorisation of sub-contractors as service-suppliers helps to identify and avoid the sources of variability.

7.6.4 Improving the usefulness of current assets

The reduction of variability linked to current assets consists in improving the usefulness of inventories of raw materials, intermediate products and completed products. The concrete goal is to reduce inventory losses due to various causes, such as spoiling, ageing, or loss. The general goal is to reduce tied-up capital and current assets. Development actions are focused to activities which directly control current assets.

7.6.5 Improving the availability of fixed assets

As a key figure, the long-term availability of an individual production machine will not reveal the whole truth. To compare two machines with the same availability: Machine A has long, irregular shutdowns, while Machine B has short, regular shutdowns. It will be seen that Machine B is better controlled since its availability is subject to a smaller variability.

Maintenance is defined as technical and administrative measures with the purpose of keeping equipment in working order and of restoring them to working order after a failure. The most essential goal of systematic maintenance is to increase the proportion of preventive maintenance in relation to corrective maintenance, and to decrease the number of shutdowns due to failure. The goal of profitable maintenance is to find an optimum between losses of profit due to failures and maintenance costs. The key problem of systematic maintenance is the dimensioning of maintenance resources and their allocation in the correct proportion between preventive and corrective maintenance. In general it is difficult to establish the total cost due to failures and to show how preventive maintenance could reduce it.

A significant obstacle to improving the availability of machines and equipment is the deficient documentation of disturbances; if implemented appropriately, it would allow the tackling of true causes behind disturbances. According to Toikka and Kuivanen (1993), *disturbance* is a state in the system which deviates from the planned or target state and forces the organisation to act in deviance to the normal. Usually, if a piece of equipment behaves abnormally, this is termed a fault, even though what is normally detected is a symptom of the fault. The danger here is that repair is only focused at removing the symptom. In order to gain a more permanent improvement, the origin and true root cause of the fault must be found, either by deduction or statistical or other methods.

7.6.6 Improving personnel attendance

The presence of the personnel resource is improved by reducing sick leaves and unauthorised absences. Whether unpaid leaves of absence are also considered in this context depends on the case. In Finnish workplaces, the volume and causes of sick leaves are actively monitored by the occupational health care staff. The aims of occupational health care, as determined by law, are:

- a healthy and safe work environment,
- a functional work community,
- prevention of work-related illness and
- maintenance and promotion of work and functional capabilities.

7.6.7 Improving the internal reliability of delivery of an activity

In this context attention is focused on the direct reduction of variability rather than on the possibilities of providing buffers through inventories, extra capacity or allocation of time. In terms of reducing the internal variability of an activity, essential points to focus on are long chains of operations and resources with high degrees of utilisation. In long chains of operations, individual instances of variability will be multiplied and accumulated (negatively).

As with processes, individual activities may also be subjected to the maturity level model. The activity's internal operations must be brought under control, the performance of operations must be predictable. In improving the maturity level of an operation, the primary issue is to stabilise operating procedures. Traditionally, this has been achieved by issuing descriptions and instructions. Since disturbances are a natural element of all activity, instructions must also include the controlled and standardised ways of dealing with emergent problems and changes in tasks. If the instructions for an operation are written by an external body, provision should be made for an eventual resistance. Resistance may take the form of active or, even worse, passive neglect of the instructions. If those responsible for an operation can be involved, to the maximum extent possible, in producing the instructions related to their duties, they need not "defend their turf". The purpose is to motivate the personnel to observe the instructions.

Speed and a high capability of producing quality go hand in hand. A rapid, controlled operation requires that all of its stages function in a controlled way and are capable of producing quality. An operation cannot be made more rapid if time must be spent to complement, correct or return the products of a previous stage. On the other hand, reducing the lead time of an operation will improve its capability of producing quality, because feedback on disturbances is immediate and corrective measures can be started rapidly (Figure 7.4).

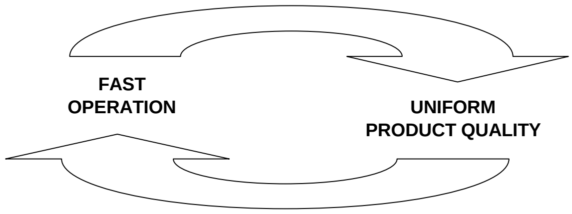


Figure 7.4 Link between the capability of producing quality and lead time of an operation.

Application of a frozen period in production

In a production driven by customer orders, the changes made to the order during the order–delivery process are extremely troublesome. The practical means of reducing the variability due to customer order changes is often the declaration of what is called a *frozen period* in production, during which the quantity or contents of customer orders may not be changed.

In the author's experience, the week-long frozen period used in many companies applying order-driven production may be realised for the first or second day of the period. Towards the end of the period, changes in the firm programme are a rule rather than an exception. If the frozen period, dependent on many variables, is unnecessarily long, there will be a need for changes on the practical level and operation will suffer a considerable variability.

If the company wants to apply a frozen period, it must be set as short as possible. The length of the period is determined by the components with a critical delivery period. It is often appropriate to increase the inventory levels of critical components in order to shorten the frozen period. In this case, the *production programme* may be updated on a rolling basis, for instance, every morning the third day's programme, etc.

Stabilising of batch sizes

Batch production is a significant source of variability. Typically, batching is seen in work stages and moves. Batch sizes should be as small as possible. The Just In Time and Lean approaches encourage a level flow of production. The purpose is to make small batches often rather than large batches rarely.

Corrections

If an operation corrects the faulty products it has produced, the corrective work has two consequences: it takes up capacity and causes variability. If corrections cannot be eliminated, corrective work must be organised to cause as little disturbance as possible. Corrective work must utilise resources which do not form a bottleneck, and the corrective operation chain must be as short as possible.

5S

The vulnerability to disturbances of an activity may be reduced by making sure that the work environment is clean and orderly. For this purpose the 5S procedure may be used, which is presented in several manuals and also modified by several companies for their own use. The main phases of 5S are (5 S for Operators 1996):

> **Seiri** (separate). Separate the necessary and the unnecessary and scrap what is not needed.
>
> **Seiton** (simplify). Organise the items left at your work station so that they are easy to locate.
>
> **Seiso** (clean). Keep machines and the work environment clean and orderly.
>
> **Seiketsu** (systematise). Develop routines for keeping order, cleaning and the monitoring of these.
>
> **Shitsuke** (standardise). Standardise the preceding phases into a procedure which you will follow continuously and develop further.

Operation structures

For the controlling of variability it is of prime importance to simplify operations and operation structures. For example, the operations included in purchasing may be simplified and streamlined by identifying and defining the purchased items requiring different purchasing routines.

Procedures may be standardised by dividing excessively large operation entities into smaller, more easily managed entities. In developing the delivery chain, the separation of activities inside the delivery process from external activities holds a key position (Luhtala et al., 1994). The purpose of activities external to the delivery process is to set the foundation for efficient activities inside the delivery process. For instance, in order to achieve world-class level, *the management* of suppliers and *purchasing* must be separated (Luhtala et al., 1994). Supplier management operates as a support operation outside the delivery process, separated from daily routines. It creates the prerequisites for an efficient purchasing activity and guarantees the possibility of profitable operation, managing such things as the choice and development of suppliers and negotiations for annual contracts. Purchasing manages the activities inside the delivery process and is responsible for its own operational efficiency. It is also responsible for delivery calls and the management of floor-level component buffers.

Resources / resource structures

The separation of resources which implement different activity chains (Processes A, B, and C) creates the conditions for stabilising the mode of operation.

Management of constraining resources

The high utilisation rates of key resources increase variability (Factory Physics, 2001). The combined effects of a high utilisation rate and an increased variability are as follows:

- the effects of congestion are multiplied,
- the impacts of the utilisation rate are not linear and
- the significance of constraint management increases.

Each operation has its individual constraint resource which determines the throughput achievable. For controlling the operation it is advantageous if the constraint can be easily identified. If the throughput of the internal operation chain of an activity is balanced by constructing the same capacity for different resources, the activity becomes extremely vulnerable. The constraint resource will be different at different times, moving around within the activity, and the conditions required for controlling the throughput will be weakened. Other operations must have a clearly higher capacity than the operation implemented by a central, difficult-to-acquire or expensive constraint resource. From the point of view of constraint management, attention is focused on the rules governing the loading of the constraint and on the control of constraint throughput. The control of constraint throughput is linked to batch sizes used, setup times and the possibilities of using alternative resources, the efficiency of which is not always readily apparent. It is essential to focus on throughput, not on the efficiency of individual operations or the productivity of individual resources.

7.6.8 Improving the internal capability of producing quality of an activity

Streamlining the capability of producing quality of different procedures can be started by analysing the work methods applied by different persons. The next step is to identify differences between best and weakest performances and to introduce best practices.

Mistake proofing (Poka-yoke)

Mistake proofing is mainly applied in the manufacturing of physical products. Four primary types of mistake proofing are proposed by Shigeo Shingo (Shingo 1982):

Elimination: Redesign the system to eliminate the chance of the error.

Facilitation: Provide methods of guidance, hard and soft, to minimize the chance of an error.

Mitigation: Lessen the effect of the error if the resulting defect gets to the customer.

Flagging: Proven methods for insuring 100 % chance of capturing and removing all defective units prior to shipment.

Statistical process control, SPC

The principles and first control cards of Statistical Process Control (SPC) were formulated as early as in the 1920s in the Bell Telephone laboratories by Walter A. Shewhart (Shainin & Shainin, 1988). SPC is an application of statistics for measuring and analysing the variation in a manufacturing process. The main focus of SPC lies on the identification of common and special causes of variability and on the determining of correct action to take in different situations. The purpose of SPC is to monitor and control the process so that its products will continuously conform with goals.

Six Sigma

The Six Sigma approach strongly focuses on reducing variability. Six Sigma is primarily a problem-driven stabilisation of activity, the solving of identified problems. Six Sigma contributes to problem solution by providing the organisation (trained for the purpose) with a shared language, a standardised mode of communication.

8 OPTIMISATION OF OPERATIONAL QUALITY

This chapter presents the approach developed during this study for the optimisation of the operational quality of the order–delivery process, for the purpose of improving the efficiency of the process. At the beginning of the chapter, the content of various concepts is defined as understood in this study. The main content of the chapter is the presentation of analyses required in identifying the development objects. At the first stage of analysis, useless activities are identified, and after that attention is focused on the efficiency of activities considered useful. The chapter closes with some examples of development actions.

8.1 Concepts and key figures associated with operational quality

Operational quality

On a general level, the operational quality of an operation may be assessed by examining the lower-level operations included in it in terms of

- *operation effectiveness* and
- *operation efficiency*.

One of the authors who have examined productivity and concepts linked to it is Hannula. He defines the difference between effectiveness and efficiency as follows: “While efficiency is related to the internal performance of a process, effectiveness can be related more to external performance.” (Hannula, 1999, p. 29)

Operation Effectiveness

Hannula, among others, has noted that effectiveness is linked to the capability of meeting customer needs: “At the conceptual level effectiveness seems to be close to the ability to produce high product quality, which is commonly defined as fitness for use as viewed by a customer or, the ability to fulfil customer’s needs”. (Hannula, 1999, p. 30)

Customers appreciate values which are useful to them. In this study, the concepts *effectiveness* and *value* are closely related. In examining operational quality, operation effectiveness is ultimately determined by the customer: effective operation increases the value recognised and valued by the customer, the customer value.

Operation efficiency

In this study, operation efficiency is determined by the ratio of the *added value of operation* and the corresponding *operation cost*:

$$\text{Operation efficiency} = \frac{\text{added value of operation}}{\text{operation cost}} \tag{12}$$

The added value achieved by the operation is determined by the added value to products achieved through the operation during a given time period. Operation cost is understood to include the cost caused by the operation during the time period corresponding to the achievement of added value. Activity-Based Costing, for instance, stresses the importance of defining the total cost caused by the activity, or *activity costs*.

Work sorts

When a product is being realised, added value is created in work carried out according to product sort. According to Eloranta (Eloranta et al., 1994), practically irrespective of job description, jobs consist of *information work*, *service work* and *traditional factory work*. Traditional factory work means tasks requiring physical skills. Information work stresses the use of intellect and of IT aids which support the intellect. The essential aspect of service work is the serving of customers, suppliers or in-house personnel with information or material. In this study, traditional factory work is termed *physical work*. Physical work processes physical products, service work processes services and information work processes information products.

Productivity

Resources carry out operations by carrying out work. In this study the concept of *productivity* is linked to the work carried out by resources; productivity is used to measure the efficiency with which the resources create products in carrying out operations. In this context, attention is focused on the productivity of work carried out by the most important basic resources:

- machine work productivity and
- manual work productivity.

In its general form, productivity is defined as the ratio between the output realised and the input used. In looking at the productivity of individual resources it is possible, for instance, to measure the output by the number of realised products and the input as the planned working hours. In practice, problems are caused by the fact that the products realised during the period in question are often difficult to compare.

Time elements of a machine work period

The time elements included in the planned working hours of a machine tool, for instance, may be defined as in Figure 8.1:

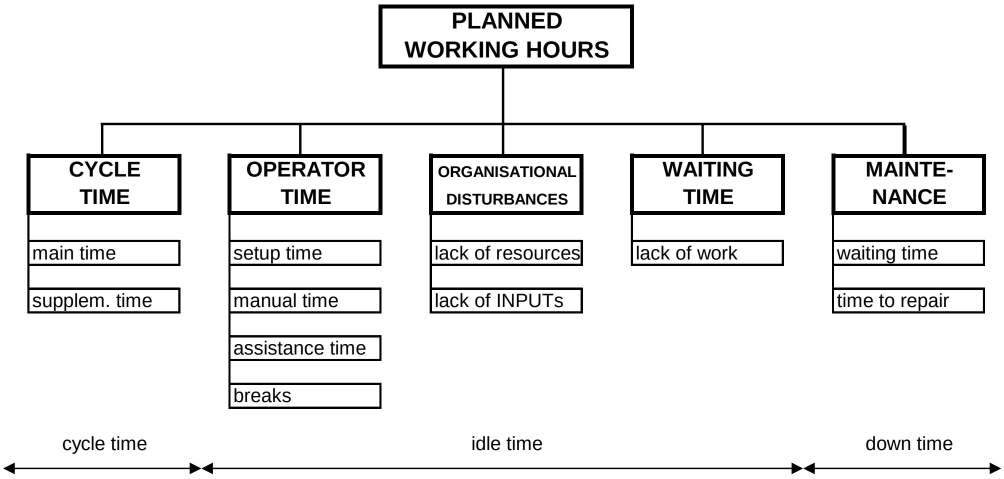


Figure 8.1 Example of time elements in the use of a machine.

Machine work productivity

Machine work productivity may be presented as the following general expression:

$$\textit{Machine work productivity} = \frac{\textit{number of realised products}}{\textit{planned working hours}} \tag{13}$$

According to the REALST model (a computerized approach to performance measurement) (Rantanen 1995, p. 51), changes in productivity consist of two measurable factors: changes in capacity utilisation and changes in efficiency.

Machine utilisation rate

Machine utilisation rate indicates the share of planned working hours used by the machine for working. The utilisation rate may be expressed by several key figures, including:

$$\textit{Utilisation rate} = \frac{\textit{cycle time}}{\textit{planned working hours}} \tag{14}$$

The volume of planned working hours is estimated using the *degree of utilisation*. The degree of utilisation may be improved by, for example, adopting a 3-shift system instead of two shifts.

Machine work method efficiency

Work method indicates the method defined for carrying out the work. In assessing *machine work method efficiency* attention is focused on how much added value the machine can achieve through working. In this context, the added value achieved is measured by the number of products realised. One of the key figures for machine work method efficiency is:

$$\textit{Machine work method efficiency} = \frac{\textit{number of realised products}}{\textit{cycle time}} \qquad (15)$$

In assessing work method efficiency, value adding products are only taken to include products which meet the quality criteria. Thus, work method efficiency in this context also includes the capability of producing quality of the corresponding methods.

The expression for machine work productivity may be extended to take the form:

$$\textit{Machine work productivity} = \frac{\textit{cycle time x number of realised products}}{\textit{planned working hours x cycle time}} \qquad (16)$$

which leads to

$$\textit{Machine work productivity = utilisation rate x method efficiency} \qquad (17)$$

The definition of productivity presented here applies to a single method. If necessary, a productivity index covering several methods may be defined for a machine, using such factors as the utilisation rate and the *average of comparative efficiencies for different methods*. The latter is determined by assessing the method efficiency of each method by comparison (by comparing to the optimal level planned or achievable) and by calculating the weighted average of the comparative efficiencies of all methods (using the cycle times of each method).

Productivity index of a machine =
utilisation rate x average comparative efficiencies of different methods (18)

If needed, the assessment of method efficiency can be made more precise by separating products which meet their quality specification from all products realised (gross) and measuring their ratio by the capability of producing quality, which leads to

Method efficiency =
method efficiency (gross) x capability of producing quality (19)

Thus, the expression of a machine's productivity may be written as:

Machine work productivity = utilisation rate
x method efficiency (gross) x capability of producing quality (20)

Time elements of a work period

In the context of *time-and-motion study*, the time elements included in a work period are defined as in Figure 8.2:

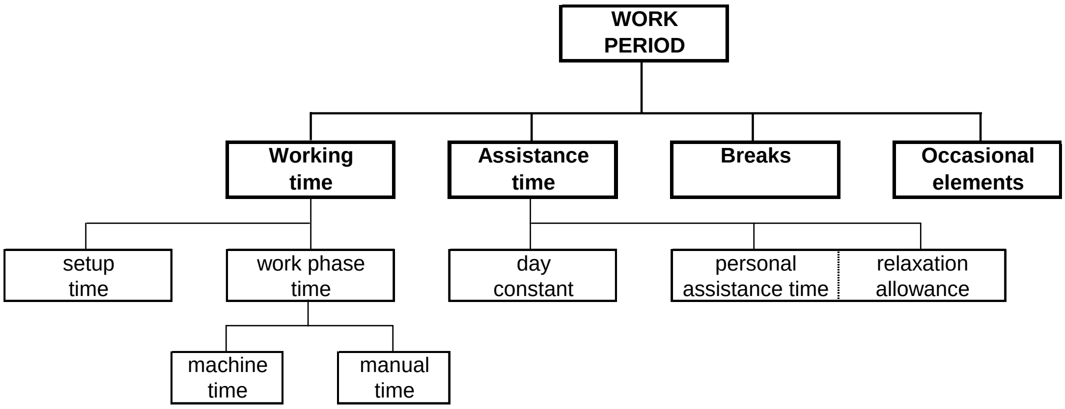


Figure 8.2 Time elements included in a work period within a personnel resource (Rationalisoinnin peruskurssi, osa 1, 1988).

Manual work productivity

If the outputs of manual work can be defined as commensurate products, it follows that the productivity of manual work may be presented in the following general form:

$$\textit{Manual work productivity} = \frac{\textit{number of realised products}}{\textit{work period}} \quad (21)$$

Generally in the connection of manual work, the productivity factors listed in REALST are augmented by the concept of *performance*. Thus, the factors of manual work productivity are:

- utilisation of working time,
- method efficiency and
- performance.

Utilisation of working time

The definition of utilisation of working time in manual work is the share of planned working hours, or the work period, which is used for working, in contrast to events which are repeated on different days, i.e., assistance time. The key figure for the utilisation of working time may be calculated as follows:

$$\textit{Utilisation of working time} = \frac{\textit{(working time + assistance time)}}{\textit{work period}} \qquad (22)$$

If the *standard times* of work for the period in question are known, the utilisation of working time may also be assessed using the standard times of work achieved and the performance:

$$\textit{Utilisation of working time} = \frac{\Sigma \textit{ standard times of work}}{\textit{work period x performance}} \qquad (23)$$

The standard time of work corresponds to the time which a skilled operator well versed in this work will need to carry out certain work, when applying the normal performance, a familiar method and in standard conditions, including assistance and preparation time. As defined by the British Standards Institution, standard time is the total time in which a job should be completed at *standard performance* (Term number 35010) (Whitmore, 1975).

Method efficiency of manual work

The key figure for method efficiency of manual work may be defined as follows:

$$\textit{Method efficiency of manual work} = \frac{\textit{number of realised products}}{\textit{(working time + assistance time)}} \qquad (24)$$

In assessing the method efficiency of manual work, realised products and value adding products are only taken to include products which meet their quality specification. Thus, method efficiency also includes the capability of producing quality of the corresponding methods.

Performance

The concept of performance describes an individual's rate of working. Performance is the ratio between the standard performance and the individual's actual work performance. If the ratio is 1,00, the individual is working at *standard performance*. Performance is affected by the worker's skill, intensity and prevailing conditions. Standard performance is defined by the

British Standards Institution as follows: “Standard performance is the rate of output which qualified workers will naturally achieve without over-exertion as an average over the working day or shift, provided they adhere to the specified method and provided they are motivated to apply themselves to their work (Term number 34001).” (Whitmore, 1975)

By including the performance in the nature of manual work, the expression for manual work productivity may be broadened as follows:

$$\textit{Manual work productivity} = \frac{\textit{(working time+ass. time) x number of realised products x performance}}{\textit{work period x (working time+assistance time)}} \quad (25)$$

which leads to

$$\textit{Manual work productivity} = \textit{utilisation of working time x method efficiency x performance} \quad (26)$$

8.2 Analysing operational quality

In examining the operational quality of the order–delivery process, the first stage is to assess the usefulness of individual activities included in the process. Once the useful, value adding activities have been identified, attention will be focused on eliminating non-value-added activities and on optimising the efficiency of value-added activity.

8.2.1 Determining the effectiveness of an activity

In defining the effectiveness of an activity, the length of the period of observation must be selected carefully. If the product range is based on such things as platforms created by long-term product development, the product is likely to contain features which are non-effective in a short-term examination.

The following constraints are noted when assessing the effectiveness of activities in the order–delivery process:

- The effectiveness of an activity is assessed on the basis of *offered value*; if the customer is offered products or product features which are not useful to them, the *offered value* will also include the corresponding non-effective added value.
- The effectiveness of an individual activity is assessed in black-and-white terms: the activity is either effective (value-added) or non-effective (non-value-added).

Activities are often so broad in scope that it is rarely possible to regard an activity as completely non-effective. It is often appropriate to divide the activity into smaller activities or carry out a similar, more detailed examination on the task level.

The definition of the effectiveness of activities included in the order–delivery process is started by dividing the activities into basic and support activities. The division is based on the definition presented under 2.2.1. The effectiveness of individual basic activities is assessed by asking the following question for each basic activity included in the order–delivery process:

> *Does the activity add to the value offered of the product, product component, product property or competitive factor?*

The effectiveness of a support activity is defined on the basis of the value of the support products achieved by it. To define the effectiveness of a support activity, the following questions are useful:

> *Who are the users of the support products achieved by the support activity?*
>
> *Will business stop, or be hindered or delayed, if the products achieved by the support activity are absent?*
>
> *Do the support products achieved by the activity support a performance which conforms with the operational success factor of the process?*

If the product architectures and operation structures (and their adaptabilities) are not compatible with each other, it is likely that the order–delivery process contains some non-effective activities.

8.2.1.1 Eliminating non-effective activities

The elimination of an activity found to be non-effective may require that the reason for its existence is determined: why is it present at all, what is the *cause of activity*? The cause of a non-effective activity is often found in nearby activities, which need to be subjected to development actions before the non-effective activity is discontinued. Table 8.1 contains examples of non-effective, non-value-added activities and their possible causes.

Organisations with a long history are likely to contain activities and tasks whose true cause no longer exists and which are only carried out "because that's how things have always been". A long career spent in the same duties may make a person blind to his or her work: it is difficult to challenge the usefulness of one's tasks, such as continuing to compile reports which are no longer useful. Once identified, such tasks and activities may be surprisingly easy to get rid of.

Table 8.1 Non-value-added activities and their possible causes.

non-value-added activity	**cause**
transport	poor layout
inspection	high variability
work supervision	centralised power and responsibility
stage-by-stage control	low level of self-control
intermediate storages	poor product flow
repeated pricing of products purchased from sub-contractors	poorly defined outsourcing strategy
repeated application planning for each order with little variation	poorly defined product policy, low level of product standardisation

Lapinleimu (2000) has mapped possible problems linked to the ideal factory in mechanical engineering, one of which he considers to be logistics. The increase in networking and specialisation in core competences increase logistics. Lapinleimu notes that transport does not increase product value, except by improving the availability of final products. To some extent, transport can even destroy value. Every logistic measure forms or causes:

- an interruption in the process,
- an interface,
- a cost and
- a potential source of disturbance.

8.2.2 Determining the actual efficiencies of activities

The definition of the efficiencies of activities only focuses on activities found to be effective. For this assessment, the activities are analysed for the capability of producing added value: how efficiently does an activity process INPUT products into OUTPUT products, how large is the share of costs of the actual added value?

$$\textit{Actual efficiency of activity} = \frac{\textit{actual added value of activity}}{\textit{activity cost}} \quad (27)$$

The realisation of an activity consumes resources, and the consumption of resources by an activity causes costs, *activity costs*.

8.2.2.1 Assessing the added value created by an activity

Assessing the added value created by the individual activities included in the order–delivery process requires that the added value created in the entire order–delivery process is determined. The analysis carried out to this end will concretise the value strategy of the company / value net: what are the shares of the key processes in the value net of the offered value achieved in the value net?

An illustrative example of the value added which is achieved through a value net's key processes and which corresponds to the offered value during a time period is shown in table 8.2.

Table 8.2 An Illustrative example of added value achieved in a value net.

	actual value of product properties	added value of physical work	added value of services	added value of information work	value of assumed image	total value
CUSTOMER PROCESS					3 000	**3 000**
PRODUCT PROCESS	5 000					**5 000**
ORDER-DELIVERY PROCESS		3 960	2 640			**6 600**
total value	**5 000**	**3 960**	**2 640**		**3 000**	**14 600**
					+ utilised value of purchases	**12 000**
					= OFFERED VALUE	**26 600**

In this context no attention is paid to the efficiency of achieving the added value or the efficiency of utilising the INPUT products purchased. For managing the cost caused by INPUT products, it is possible to apply the method of managing resource costs, presented in the following chapter.

The added value created through the product realisation can be defined through comparison. Comparison can enable the definition of a "current price" for product realisation (manufacturing). In practice, comparisons may be effected with the help of other actors pursuing a similar activity, such as sub-contractors. The added value created in manual work may also be estimated as the result of the standard times of work and the current unit prices of resources consumed in the work.

The relative activity-specific shares of the added value created in the order–delivery process may be defined as follows:

1. Define the total added value created in the order–delivery process
2. Rank the activities in order of importance on the basis of the volume of added value created
3. Assess the shares of each activity of the added value created:
    - assess the share of the total added value assigned to the activity which creates the greatest added value

- assess the share of the total added value assigned to the activity which creates the lowest added value
- assess the share of the total added value assigned to the other activities

Even if this assessment does not show that individual activities can create significant added value, it must be remembered that, according to the assessment conducted during modelling, the existence of each effective activity is important in forming the value of the product. If only one member of a relay race team stops, the race will stop, or the other team members must be able to take up a share of the remaining distance. An example of added values created by activities in the order–delivery processes is presented in Table 8.3.

Table 8.3 An illustrative example of added values created by activities.

A	B	C	D	E	F
ACTIVITY	**Added value of physical work**	**Added value of services**	**Added value of information work**	**Total added value**	**Share of added value of process**
order processing		900		**900**	13,6 %
material management		400		**400**	6,1 %
purchasing		350		**350**	5,3 %
production management		330		**330**	5,0 %
part manufacturing	1 320			**1 320**	20,0 %
assembly	2 640			**2 640**	40,0 %
delivery		660		**660**	10,0 %
ADDED VALUE OF PROCESS	**3 960**	**2 640**		**6 600**	

In the process described in Table 8.3, the activities realising order-specific commercialised services are defined as basic activities.

The definition of added value created in an activity is linked to a problem which is also noted with in key figures for productivity based on added values and financial values. If the prices of INPUT and OUTPUT products are changed because of the development of exchange rates, the added value defined on the basis of these rates will also change, though the operation does not necessarily change at all.

8.2.2.2 Determining activity costs

In this context, activity costs are taken to include both *direct* and *indirect* costs. The activity-based cost structure of a process describes the shares of individual activities of the total process cost (Table 8.4). The process cost is the sum of the activity costs of activities included in the process.

Activity costs are defined for the same time period as the added value achieved.

Table 8.4 An illustrative example of activity costs.

A	G	H
ACTIVITY	**Actual activity cost**	**Share of process cost**
order processing	**360**	6,3 %
material management	**360**	6,3 %
purchasing	**480**	8,4 %
production management	**180**	3,2 %
part manufacturing	**840**	14,7 %
assembly	**3 180**	55,8 %
delivery	**300**	5,3 %
PROCESS COST	**5 700**	

The purpose of Activity-Based Costing is to trace indirect costs to selected cost objects (products). The definition of desired product-specific costs requires that the cost of activities needed in realising products, *activity costs*, are defined. If data derived from Activity-Based Costing is not available, an adequate calculation model must be constructed. This should assess the resource amounts consumed by each activity and calculate the activity costs on the basis of resource consumption and the unit costs of resources.

8.2.2.3 Determining efficiencies

By combining the results of Tables 8.3 and 8.4, it is possible to calculate the actual efficiencies of individual activities, as shown in Table 8.5.

Table 8.5 An illustrative example of actual efficiencies of individual activities.

A ACTIVITY	E **Total added value**	G **Actual activity cost**	I = E / G **Actual activity efficiency**
order processing	900	360	**2,50**
material management	400	360	**1,11**
purchasing	350	480	**0,73**
production management	330	180	**1,83**
part manufacturing	1 320	840	**1,57**
assembly	2 640	3 180	**0,83**
delivery	660	300	**2,20**
TOTAL / PROCESS	**6 600**	**5 700**	**1,16**

8.3 Identifying development objects

In identifying development objects, the development potentials for efficiencies achievable by optimisation are assessed, the appropriate level of development is identified, the activities to be developed are selected and finally, factors affecting the non-efficiency of the activities are identified.

8.3.1 Determining the optimal efficiencies of activities

At this stage, the *targeted optimal efficiencies* are defined for activities found to be useful. These may be based on best practices found in the value net in question or on comparative data concerning similar practices in other value nets / companies.

The defined targeted optimal efficiencies must also contain a potential for improvement, to concretise the strategic choices linked to the performance potential of the value net. Value nets and individual companies who rely on operational quality as an operational success factor, must identify the activities in which they need to strive for a superior efficiency level. Activities which realise core competence must generate plenty of added value efficiently. In the case of a value net combining several companies and the related order–delivery process, each activity should be realised by the best possible actor. Table 8.6 presents an illustrative example of actual and optimal efficiencies.

Table 8.6 Optimal efficiency of activities.

A	E	G	I	J
			= E / G	
ACTIVITY	**Total added value**	**Actual activity cost**	**Actual activity efficiency**	**Targeted optimal efficiency**
order processing	900	360	2,50	**3,00**
material management	400	360	1,11	**1,10**
purchasing	350	480	0,73	**1,10**
production management	330	180	1,83	**1,10**
part manufacturing	1 320	840	1,57	**1,80**
assembly	2 640	3 180	0,83	**2,00**
delivery	660	300	2,20	**2,20**
TOTAL / PROCESS	**6 600**	**5 700**	**1,16**	**1,82**

Comparisons must be extremely careful in terms of selecting objects of comparison with the same content and of ensuring that the efficiency factors determined are comparable. Comparisons are made more difficult by the fact that data of the kind presented here is not easily accessible. Comparisons also reveal information on new, more efficient modes of operation. The optimisation of the target efficiency also means that the definition of target level includes the cost of optimisation.

8.3.2 Identifying the level of development

At this stage, the adequacy of the development potential is assessed. On the basis of the targeted optimal efficiencies, Table 8.7 determines the corresponding targeted optimal efficiency for the order–delivery process. If the development potential looked for through optimisation is adequate for the goals set, process optimisation may be continued. If the potential is found to be inadequate, process reengineering must be started. If the efficiency realised in the process is already sufficiently close to the goals set, attention may be focused on the operational success factor with the next highest priority in the order–delivery process.

8.3.3 Selecting activities for development

In absolute terms, the volume of added value depends on process throughput and process efficiency. This study focuses on the optimisation of process efficiency.

The selection of activities for development is based on the development potential linked to the efficiency of activities defined as useful, weighted with the volume of added value created by the activity.

Table 8.7 combines the analyses included in Tables 8.3, 8.4, 8.5 and 8.6, following the principle presented in Figure 6.2. Since the product and thus the added value created in the order–delivery process are considered mainly as given, the improvement of efficiency will strive to reduce the costs caused by the activity. The primary purpose is not to focus on a reduction of activity costs, but to create added value as efficiently as possible. If the primary focus lies on cost reduction, a core competence with strategic importance may be overlooked.

Column K in Table 8.7 defines the targeted cost per activity, defined on the basis of the added value achievable and the targeted efficiency. The corresponding absolute savings potential realised in the activity is defined in Column L, and the proportionate savings potential in Column M.

Table 8.7 Selection of activities for development to optimise process efficiency.

A	E	G	I	J	K	L	M
			= E / G		= E / J	= G - K	= L / G
ACTIVITY	**Total added value**	**Actual activity cost**	**Actual activity efficiency**	**Targeted optimal efficiency**	**Targeted activity cost**	**Absolute potential saving**	**Comparative potential saving**
order processing	900	360	2,50	3,00 →	300	**60**	17 %
material management	400	360	1,11	1,10 →	364	**-4**	-1 %
purchasing	350	480	0,73	1,10 →	318	**162**	34 %
production management	330	180	1,83	1,10 →	300	**-120**	-67 %
part manufacturing	1 320	840	1,57	1,80 →	733	**107**	13 %
assembly	2 640	3 180	0,83	2,00 →	1320	**1 860**	58 %
delivery	660	300	2,20	2,20 →	300		
				→			
				→			
				→			
TOTAL / PROCESS	**6 600**	**5 700**	**1,16**	**1,82**	**3 635**	**2 065**	**36 %**

Table 8.7 shows that development actions must be focused on the activity *Assembly*. Assembling clearly includes the greatest potential for savings in activity costs: it achieves 40 % of the total added value, it is the second least efficient activity in the whole process, and its targeted optimal efficiency is above average. In the same way, less attention may be focused on *Production management*, since its share of the added value realised is the second smallest, and its current efficiency is already above target.

8.3.4 Identifying factors detrimental to operational efficiency

Development actions to improve the efficiency of an activity are presented in the block diagram shown in Figure 8.3. As is the case for the non-value-added, useless activities in the process, the useless tasks included in an activity should also be identified. The next task is to review the appropriateness of the INPUT products of the activity.

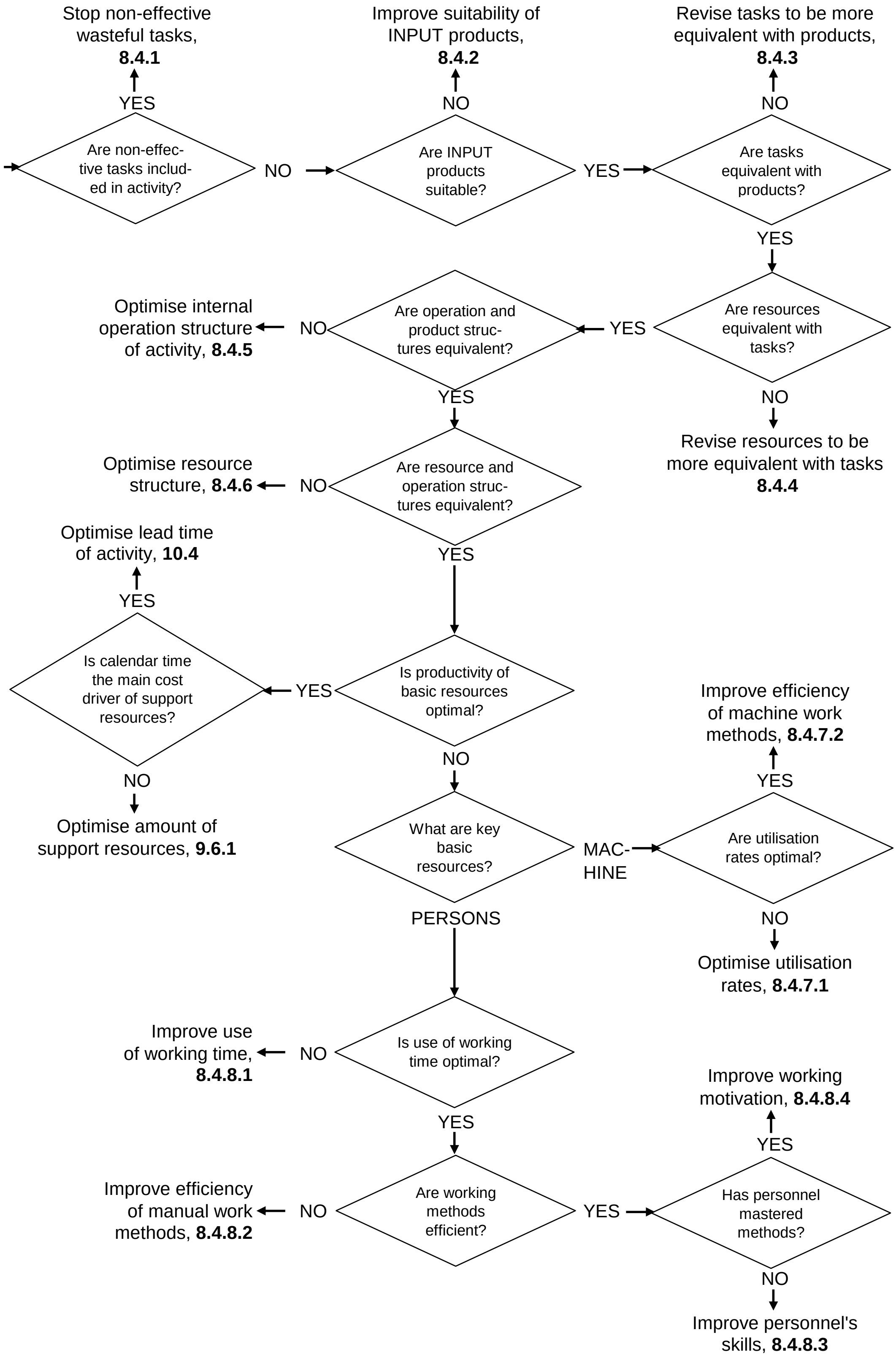


Figure 8.3 Identification of actions to improve the efficiency of an activity.

The appropriateness and optimality of tasks is assessed by comparing them with best and good practices. The appropriateness and optimality of resources will be assessed in a similar manner. The internal operation structure of the activity and the corresponding resource structure determine the form of production of the activity. The operation structure is examined before the resource structure because of the primary nature of the correspondence between operation structure and product architecture. The resource structure has an essential impact on the controllability of an activity. It is appropriate to examine controllability before improving the internal control of the activity. Finally, attention is focused on the productivity of core resources. The numbering of development actions in Figure 8.3 refers to the sections in this chapter of the report.

8.4 Optimising the efficiency of an activity

Under this heading a number of measures are presented as examples of how to eliminate factors detrimental to the efficiency of an activity. The optimisation of the efficiency of an activity follows the procedure set out in Figure 8.3.

8.4.1 Eliminating useless tasks

The development of the order–delivery process began with the identification of useless activities within the process. The development of an individual activity follows the same approach. Before the identification of useless tasks, the task chain which forms in the activity must be modelled. It must be ascertained that all tasks included in the activity are definitely noted in the description. The causes of useless tasks are often found in the near vicinity; for instance, when the continuous flow of manufacturing is not assured there will be a need for transport, unspecified rules of co-operation with a supplier may cause the need to inspect goods supplied, etc.

Toyota has defined seven kinds of waste (Hines & Taylor, 2000), which may be of help in identifying useless tasks:

- overproduction,
- defects,
- unnecessary inventory,
- inappropriate processing,
- excessive transportation,
- waiting and
- unnecessary moves.

8.4.2 Improving the suitability of INPUT products

The optimal performance of an activity requires that the INPUT products are suitable. Since an activity does not always select all of its INPUT products and their suppliers, it is unable to directly influence the suitability of all INPUT products. The only channel of influence in this case is the provision of feedback to the supplier of INPUT products and the entity which selects them.

INPUT products acquired from outside the value net

The improvement of the suitability of an INPUT product consists of optimisation between product price and product features. As a customer, the value net may assess the suitability of its purchases with a *value analysis*, for instance.

Information products

Although the method developed in this study regards the product as given, it should be noted that the production-friendliness of products improves the suitability of product information.

The suitability of an information product is affected, among other things, by whether the information product arrives in the correct format and with the correct content, whether the information products need modification before they can be processed further, etc. The effect of unsuitable product information used as INPUT products in realisation is illustrated by the following example: The need for steel plate included in the product is defined by product planning as kilograms, although in practice, part manufacturing uses square metres. For hot-rolled steel plate, for instance, the difference depending on whether square metres or kilograms are used may be as high as 10 %.

The tolerances selected for the dimension drawings of physical products have a significant effect on the suitability of product specifications. In assessing the suitability of tolerances, attention is primarily focused on whether the tolerances correspond to genuine customer needs. After this, the tolerances selected are assessed with regard to process performance capability.

The controlling of tasks and work phases through an independent controlling function should be avoided, because the schedules which form the basis of control are always a forecast of future needs. The importance of forecasts should be diminished by shortening lead times and using pull control.

In developing the management of delivery nets, a great deal of attention should be focused on controlling them and on the transmission of control information. A frequent aim is that all actors receive the same information without any intervening filters. Leaving aside the forecasting practices themselves, the quality of sales forecasts may be improved by, for example, improving the personnel's motivation for this activity and speeding up the flow of information.

8.4.3 Optimising the suitability of tasks

The necessary operations and operation structures are determined by the products realised and their product architectures. In the same way, the necessary resources and resource structures are determined by the operations and operation structures.

When assessing the optimality of operations, the first stage is to identify other options for realising the product or product feature. The options should be examined independently of existing resources and the constraints posed by them. The following stage is to determine the optimal resources needed for the optional modes of operation, and the corresponding cost. Among the options thus formed it should be possible to identify the combination of products, operations and resources which is the most appropriate for the overall process. In practice, the choice of possible methods is often constrained by the current resources (the high cost of changing resources).

8.4.4 Optimising the suitability of resources

Lapinleimu assesses the *adaptability* of production equipment from the viewpoint of modifying the product range. The possibility of modifying the production equipment when modifying the product range awards a strategic reliability for the investment, and the creation of resources unsuitable for the new product range is avoided. According to Lapinleimu, the technical flexibility of the production equipment in a metal workshop consists of the following (Lapinleimu, 2001):

- setup speed,
- multi-functionality capability, which supports one phase manufacturing, and
- a broad family of components which can be manufactured.

If the suitability of the existing equipment cannot be improved, the only remaining alternative is to invest in more suitable machinery. Because accurate long-term forecasting is difficult and uncertain, priority is given to equipment which can be used even after modifications to the product range. Lapinleimu calls this strategic security (Lapinleimu, 2001).

One way of examining the profitability of planned investments and the suitability of new resources is to estimate the total cost of investment, to trace the cost to the products to be realised and then examine product profitability before and after the investment.

If the personnel's skills do not correspond to the operations, investments must be made to develop them.

8.4.5 Optimising the internal operation structure of an activity

The internal operation structure of an activity affects its controllability. The controllability of production means the capability of the production system of achieving the goals set for it by the management (Eloranta & Räisänen, 1986). In principle, the controllability of production depends on three sets of variables:

- the structure of the production system,
- the adequacy of the control variables, and
- the behaviour of external variables.

The better the match between the product architecture and the operation and resource structures, the better possibilities there exist for a self-controlling activity. A good match means, in physical products, that manufacturing cells and workshops correspond to modules and/or that the manufacturing of whole modules is outsourced. As stated above, this requires a stable product architecture, which can be achieved by modularity.

8.4.6 Optimising the resource structure

The operation and resource structures of the activity combine to determine its form of production. It must be ensured that the production form of the activity corresponds to the value and competitive strategy selected. In Lapinleimu's opinion, repeating batch production and mass production will converge (Lapinleimu, 2001):

CURRENT:		**FUTURE:**
Unique production	⇨	Unique production with system prerequisities • rapid design • system facilities • direct manufacturing according to design
Repeating batch production	⇨	Flexible continuous production
Mass production	⇨	

Repeating batch production will change in principle to become flexibly continuous. Unique production will be developed to include as many principles of continuous production as possible.

In traditional functional manufacturing, the resources are organised on the basis of competences. In a functional resource structure, competences have the best opportunity of becoming core competences and accumulating. Other advantages of a functional organisation are high productivity, based on the high utilisation rate of capacity, and flexibility. Because a functional resource structure is not based on the product architecture or the operation structure, it is flexible with regard to changes in them. The drawbacks of a functional resource structure are a slow throughput and a considerable need of control tasks.

According to Schonberger, a product-based factory layout is always better than a functional layout. If cells are used, they should be U-shaped and the production lines should not be straight, unless special reasons exist for keeping them straight (Schonberger, 1990).

Hitomi suggests that the factory layout may be determined with the help of the Q/P ratio, in which Q (production Quantity) denotes the quantity of products realised during the period in question and P (number of Products) denotes the number of different products realised during the period in question (Hitomi, 1990, p. 278). Hitomi's Q/P ratio measures the flexibility of the product architecture. With high Q/P ratios, product-based (assembly line) solutions are to be recommended, while with low Q/P ratios a functional layout is used; between these two extremes, a cell layout is used.

As regards organising personnel resources to correspond with the operation structure, the fashion in the 1990s was to speak of teams.

8.4.7 Improving the productivity of machine work

The efficiency of an activity is essentially affected by the productivity of its bottleneck resources. A resource constitutes a bottleneck if its capacity is equal to or smaller than its demand. The potential of use of a resource which is not a bottleneck is not determined by its own capacity, but by some other constraint present in the activity. According to Goldratt and Cox (1987), these rules should not be applied to optimise the use of each resource for the activity. A locally optimised system is not optimised at all; it is a very inefficient system. Similarly, every hour lost because of a bottleneck resource is lost for the whole activity (process). In a short-term examination, an hour saved for a resource which is not a bottleneck has no value.

8.4.7.1 Optimising the utilisation rate of machines

As noted under 7.6.7, increasing the utilisation rate of a key resource to its maximum is not always optimal because of the multiple effects of increased variability.

When improving the utilisation rate of machines, the relative shares of operator, disturbance, waiting and maintenance times of the planned working hours are decreased, which will increase the relative share of cycle time. Before operator time can be effectively influenced, it needs to be analysed as to its elements, and the relative shares of preparation, manual, assistance and break times must be determined. According to the principles of continuous improvement, the elimination of disturbances requires analyses of disturbance rates and causes behind them. Theoretically, bottleneck resources will not involve waiting times, because by its very nature a bottleneck does not wait for the products, but the products queue for access to the resource. If, however, waiting time does appear, it is due to the fact that the bottleneck moves inside the activity. Maintenance planning involves the optimisation of corrective, preventive and improving maintenance. Maintenance was discussed under 7.6.5.

The simple monitoring of utilisation rates by means of continuous and visible observation may bring about a decisive improvement. Moreover, training, during which the significance of the utilisation rate of the bottleneck resource for the efficiency of the whole activity is explained, may shed light on the importance of the matter.

8.4.7.2 Developing the methods of machine work

The methods used by bottleneck resources should be developed as far as possible. The improvement of the methods of machine work improves the processing during main time and minimises the share of supplement time. Supplement time may be shortened by the selection of suitable methods.

8.4.7.3 Determining the productivity development of machine work by calculation

Let us look an input consisting of the planned working hours for one shift. The productivity elements of machine work have developed as follows:

Utilisation rate:	50 % → 60 %	+ 20 %
Method efficiency:	10 pcs/h → 12 pcs/h	+ 20 %

BEFORE:
50 % x 8 h/shift x 10 pcs/h = 40 pcs/shift

AFTER:
60 % x 8 h/shift x 12 pcs/h = 57.6 pcs/shift + 44 %

Thanks to the 20-% increase in both elements of productivity, the productivity of machine work in the example improved by as much as 44 % (120 % x 120 % = 144 %).

8.4.8 Improving the productivity of manual work

The examination of the productivity of manual work traditionally focuses on the persons implementing basic operations in production. Although the terminology used is related to physical work, the same principles are also useful in information and service work.

8.4.8.1 Improving the utilisation of working time

The utilisation of working time is improved by reducing the share of breaks and disturbance time of the available working hours. Breaks are partly affected by prevalent corporate culture, work conditions and personal motivation. Before breaks can be reduced, the mechanism affecting them needs to be identified. Eliminating disturbances requires that they are identified. Section 7.6.3.1 presented an example of disturbances in assembly. A similar method may be used to study the disturbance rate of any task, and once the disturbances have been identified, development actions can be targeted correctly.

8.4.8.2 Developing the methods of manual work

A rough division into stages of method development is:

- definition of the purpose of work,
- description of work, definition of method,
- critical examination of work,
- critical examination of smaller sections of work and
- for remaining sections of work:
    - development,
    - combining and
    - mechanisation / automation.

The main weight in the development of manual work methods lies on the continuous development and innovative improvement carried out by the operators themselves. They are often the best experts of their own work, and by assuming the responsibility for the development of work methods they will also commit themselves to the improvements.

To visualise and monitor continuous improvement (CI), a device frequently used in Finland is a *JP-board* (JP = jatkuva parantaminen, the Finnish for ´continuous improvement´). The board may be in the charge of a designated person with the task of activating and maintaining the development of his/her team and to update the board at set intervals. The team will have a regular short meeting by the board (for instance, once every two weeks).

Unfortunately, CI cannot always be stabilised as a practical routine, or the rate of development achieved by CI is not sufficient. If so, separate method development work and development projects are needed.

At best, the revision of work methods is genuinely creative. At worst, established power structures and corporate culture can undermine creativity through the excessive control of persons with ideas, through a negative climate, lack of confidence and denigration of the ideas expressed. The flow of ideas may also be supported with computer aids and various simple techniques, such as *brainstorming*.

8.4.8.3 Developing competence

Personnel competence may be improved by training and education. This can be managed by external bodies or in-house, in which case an operator may, for example, learn new tasks as the assistant of a senior operator. External training or education should never be confused with rewards even of an unofficial nature.

It should be noted that even skilled workers may have systematic faults in their work methods. This has been observed, for example, when studying the sources of measurement errors with a Repeatability & Reproducibility (R&R) test; in some cases it has been noted that even skilled operators with a lengthy experience have systematically carried out the measurements incorrectly.

In a flexible manufacturing environment, multi-skilled operators become more important. Some companies with an incentive pay system have included the number of tasks mastered by a person as a criterion. When drawing up development and training plans for individuals and teams, various competence and skills matrices can be used.

8.4.8.4 Improving work motivation

People's motivation may be improved by increasing their awareness of the importance of their work as part of a larger whole. Awareness of the overall whole will help people to focus their attention on matters which are important for the bigger picture. The personnel's motivation can be expected to increase as their own opportunities of exerting an influence are improved.

The fact that a team-based method of work improves motivation is based on more independent work methods and the improved opportunities of influence available to team members. The starting-point is that teams with motivated members should have enough responsibility and power to be able to organise their tasks flexibly according to the needs of each situation. A team can properly be said to exist when two or more people interact and consciously co-operate to reach a shared goal. Sharing the same physical space is not enough to make a team, if the people placed close together do not consciously co-operate to reach a goal and do not interact for this purpose.

Work motivation is strongly affected by the feedback provided. The feedback from a superior to a subordinate should

- focus on the way of acting instead of on the person,
- be constructive instead of negative,
- be based on facts and be accurate – not generalising or implicit,
- only focus on matters which the recipient can influence by their own acts, and
- be given immediately, yet in private.

The manner of providing feedback will determine whether it is accepted and taken on board.

The appraisal discussions between superiors and subordinates analyse and collate all factors important for improving the performance. The purpose of an appraisal is to improve the mutual collaboration of superior and subordinate and work as team member, and to support the goal-orientation of work. The main purpose of the appraisal is to agree on goals and measures to improve performance and for personal development.

Motivation can also be affected by an incentive pay system. An incentive pay system guarantees the employee a better pay for extra efforts to reach overall goals. As far conditions allow, incentive pay systems should take note of individual and team performance and the improvement of performance.

8.4.8.5 Determining the productivity development of manual work by calculation

Let us look at an input consisting of a work period of one shift. The elements of productivity of manual work show the following development in this illustrative example:

Utilisation of working time:	4 h/shift	→	5 h/shift	+ 25 %
Method efficiency:	10 pcs/h	→	12 pcs/h	+ 20 %
Performance:	1,00	→	1,05	+ 5 %

BEFORE:
4 h/shift x 10 pcs/h x 1,00 = 40 pcs/shift

AFTER:
5 h/shift x 12 pcs/h x 1,05 = 63 pcs/shift + 58 %

Thanks to the development achieved in all elements of the productivity of manual work, the productivity of manual work in the sample case improved by as much as 58 % (125 % x 120 % x 105 % = 158 %).

9 OPTIMISATION OF RESOURCE COSTS

This chapter presents an approach developed during this study to optimise resource costs. The first part of the chapter defines the content of various concepts as they are understood in this study. The main weight of this study lies on the analyses needed to identify development objects and on the identification of saving potentials. The chapter ends with examples of development actions to optimise resource costs.

In operational business activity, costs are based on the quantities of consumable/existing resources and the unit costs of resources, and on the quantities and prices of INPUT products to be purchased. The quantities of resources consumed depend on the volume of business, operational quality and speed. The unit cost of resources is affected by the optimisation of resource costs. In the context of resource cost optimisation, the examination mainly focuses on the economy and correct quantity of resources. The resources examined here are selected on the basis of three factors:

- size of resource costs,
- optimality of resource economy and
- optimality of resource amount.

Attempting to affect resources only on the basis of the costs caused by them includes an obvious risk of partial optimisation. However, the ability of resources to create added value is not examined in this context. The appropriateness of resources was examined in the context of optimisation of operational quality. When carrying out the *comparisons* included in the analyses presented in this chapter it must be ensured that the objects compared are commensurable or, alternatively, the eventual dissimilarity of resources is taken into account when defining the values of the key figures determined.

9.1 Concepts and key figures associated with resource costs

Resource cost

Resource cost may include a flexible and/or a fixed element. The *flexible resource cost* varies according to the amount of resource consumed. The *fixed resource cost* is created primarily on the basis of the existing volume of resource without the direct influence of the amount of resource consumed. Resource cost may be defined as the result of the unit cost of resource and the resource amount:

$$\textit{Resource cost} = \textit{Unit cost of resource} \times \textit{Resource amount} \qquad (28)$$

The *actual resource cost* is defined on the basis of the *actual unit cost of resource* and the *actual resource amount*.

Correspondingly, the *optimal resource cost* is formed as the result of the *optimal unit cost of resource* and *optimal resource amount*.

Unit cost of resource

In principle, the unit cost of resource describes the price paid for the unit used to measure resource consumption. The aim is to determine a practical key figure for the resource consumption which will enable *comparison*.

The *actual unit cost of resource* may be determined on the basis of the price paid for the resource or by dividing the (annual) resource cost by a quantity which measures the (annual) consumption of the resource or its total volume or otherwise serves as the basis for the resource cost.

The *optimal unit cost of resource* is understood as the optimal unit cost of a resource which has an equal value, is capable of the same performance and may be implemented without radical changes.

Resource amount

The *actual resource amount* corresponds to the amount of resource, either variable according to consumption or fixed, which has caused costs in the entity studied.

The *optimal resource amount* is the quantity of a resource which has an equal value, is capable of the same performance, may be implemented without radical charge and is optimal in terms of what is expected of the resource amount: absence of operational disturbances, eventual strategic goals set for the resource amount, resource costs, etc.

Resource economy

In this study, the assessment of resource economy is based on the comparison of prices paid for the resource (unit cost of resource).

Optimality of resource economy

The *optimality of resource economy* measures the share of the optimal unit cost of resource of the actual unit cost of resource:

$$\text{Optimality of resource economy} = \frac{\text{optimal resource unit cost}}{\text{actual resource unit cost}} \qquad (29)$$

A 100-% optimality of resource economy means that the actual resource cost is optimal.

Saving potential based on resource economy

The saving potential based on resource economy is determined as the difference between actual resource cost and the resource cost based on optimal unit cost of resource:

actual resource cost
- resource cost based on optimal resource unit cost
= Saving potential based on resource economy (30)

Resource utilisation

Actual resource utilisation measures the amount of resource needed as a share of the actual total amount of resource:

$$\text{Actual resource utilisation} = \frac{\text{resource amount needed}}{\text{actual resource amount}} \qquad (31)$$

Optimal resource utilisation measures the amount of resource needed as a share of the optimal amount of resource:

$$\text{Optimal resource utilisation} = \frac{\text{resource amount needed}}{\text{optimal resource amount}} \qquad (32)$$

Optimality of resource amount

The degree of optimality to which the cost-causing resource amount is utilised may be estimated with the help of either *Optimality of resource amount* or *Optimality of resource utilisation*. These key figures are used to measure the extent to which the resource is being utilised in comparison to optimal practice:

$$\text{Optimality of resource amount}$$

$$= \frac{\text{optimal resource amount}}{\text{actual resource amount}}$$

$$= \frac{\text{optimal resource amount x resource amount needed}}{\text{actual resource amount x resource amount needed}}$$

$$= \frac{\textit{resource amount needed}}{\textit{actual resource amount}} \times \frac{\textit{optimal resource amount}}{\textit{resource amount needed}}$$

$$= \textit{actual resource utilisation} \times \frac{1}{\textit{optimal resource utilisation}}$$

$$= \frac{\textit{actual resource utilisation}}{\textit{optimal resource utilisation}}$$

= Optimality of resource utilisation (33)

A 100-% optimality means that the actual practice is optimal.

Saving potential based on resource utilisation

The saving potential based on resource utilisation is formed as the difference between the actual resource cost and the resource cost based on the optimal resource amount:

actual resource cost
- resource cost based on optimal resource amount
= Saving potential based on resource utilisation (34)

Optimality of resource cost

The *optimality of resource cost* is determined on the basis of the optimality of resource economy and the optimality of resource amount:

Optimality of resource cost

$$= \frac{\textit{optimal resource cost}}{\textit{actual resource cost}}$$

$$= \frac{\textit{optimal resource unit cost} \times \textit{optimal resource amount}}{\textit{actual resource unit cost} \times \textit{actual resource amount}}$$

$$= \frac{\textit{optimal resource unit cost}}{\textit{actual resource unit cost}} \times \frac{\textit{optimal resource amount}}{\textit{actual resource amount}}$$

= *optimality of resource economy* x *optimality of resource amount* (35)

Saving potential based on optimal resource cost

The saving potential based on optimal resource cost consists of the difference between actual resource cost and optimal resource cost:

$$\begin{array}{l} \textit{actual resource cost} \\ \underline{\textit{- optimal resource cost}\qquad\qquad\qquad\qquad} \\ \textit{= Saving potential based on optimal resource cost} \end{array} \qquad (36)$$

9.2 Determining resource costs

A resource-based cost structure is used to find out the allocation to different resource sorts / resources of the total cost during a given time period. In this context, resources are grouped into resource sorts which are appropriate for the examination. The resources included in a resource sort should behave as homogeneously as possible in terms of costs and must share a set of key figures measuring the unit cost and utilisation of resource (to be given below). It is often appropriate to treat crucial and expensive machinery as separate resources. Similarly, it may be appropriate to separate top-level employees into a separate subgroup of the monthly-paid employees.

Resource costs should include all costs directly caused by the consumption and/or existence of the resource in question (in this context, the cost of support resources is not allocated to basic resources, as is done when using *cost pools,* as in Activity-Based Costing).

> **Personnel:** The cost of personnel resources include wages and salaries paid and the associated indirect costs, fringe benefits, and eventual overtime, rewards and bonuses.
>
> **Energy:** The resource cost of energy consists of the purchased quantities of each energy sort multiplied by the corresponding purchase prices, including eventual transport costs and statutory charges.
>
> **Current assets:** The resource cost corresponding to current assets includes the current rate for tied-up capital, depreciation of current assets and loss.
>
> **Fixed assets:** The resource cost corresponding to fixed assets includes the current rate for tied-up capital and the annual depreciation of fixed assets. Tied-up capital should primarily be defined on the basis of market values. If the property no longer has a residual book value and it is still in use, it will have a market value. The capital corresponding to market value may be released by selling the property.
>
> **Liquid assets:** The resource cost corresponding to liquid assets includes the current rate paid for tied-up capital and other financing costs.

Table 9.1 presents the annual resource cost of an imaginary company, broken down by resource sort / resource.

Table 9.1 Resource sorts and corresponding resource costs.

A	B	C
RESOURCE	**Actual resource cost**	**Share of total costs**
personnel, monthly paid	**210**	20 %
personnel, hourly paid	**240**	23 %
energy	**33**	3 %
current assets/materials	**16**	2 %
current assets/WIP	**25**	2 %
current ass./finished prod.	**60**	6 %
fixed assets/machines	**160**	15 %
fixed assets/ADP	**85**	8 %
fixed assets/buildings	**135**	13 %
other fixed assets	**17**	2 %
liquid assets/receivables	**33**	3 %
liquid assets/advances	**8**	1 %
liquid assets/cash	**9**	1 %
OTHERS	**9**	1 %
TOTAL	**1 040**	

It makes at this stage sense to estimate whether the weighting of resource costs corresponds to the weighting of core competences according to the business idea. If, for instance, the company has extensively outsourced operations outside its core competence, the cost effect of this on resources previously consumed in these operations must be examined with particular care.

9.3 Assessing the optimality of resource economy

The assessment of the optimality of resource economy is based on *benchmarking*, in which the unit costs of resources are compared to the *optimal unit costs* attainable. When comparing the actual unit costs of resources in different companies it must be remembered that the resources used by different companies are not always directly comparable with each other. The safest method is to acquire comparison data on entities which use similar resources that would be exchangeable in principle with one's own company.

The assessment of resource economy is based on the division into resource sorts carried out when assessing resource costs. For each resource sort, the units used in assessing their unit cost are determined:

Personnel: The costs of personnel resources are most often tied to calendar time, and their unit costs can be described by such units as €/month, €/h.

Energy: It is most appropriate to determine a commensurable unit for the unit costs of different energy sorts, such as €/MWh.

Different types of assets: The unit cost of a type of assets may be assessed by the share of (annual) total cost for each type calculated as a percentage of the average tied-up capital.

Table 9.2 compares the *actual unit costs of resources* to the corresponding *optimal unit costs of resources* which could be attained. Comparison data is used to define the corresponding *optimalities of economy*. The table also presents the savings potential related to resource costs based only on the optimality of economy.

Table 9.2 Optimality of resource economy. The values of key figures given in the table are not based on actual data.

A RESOURCE	B Actual resource cost	D Unit of resource cost	E Actual unit cost of resource	F Optimal unit cost of resource	G = F / E Optimality of resource economy	H =(1-G) x B Saving potential based on economy
personnel, monthly paid	210	€/month	**4 600**	**4 000**	**87 %**	27
personnel, hourly paid	240	€/hour	**24,00**	**22,20**	**93 %**	18
energy	33	€/MWh	**33**	**20**	**61 %**	13
current assets/materials	16	%	**10,0 %**	**7,0 %**	**70 %**	5
current assets/WIP	25	%	**9,0 %**	**6,5 %**	**72 %**	7
current ass./finished prod.	60	%	**8,0 %**	**6,0 %**	**75 %**	15
fixed assets/machines	160	%	**22,7 %**	**19,3 %**	**85 %**	24
fixed assets/ADP	85	%	**39,3 %**	**38,3 %**	**97 %**	2
fixed assets/buildings	135	%	**11,0 %**	**10,0 %**	**91 %**	12
other fixed assets	17	%	**26,0 %**	**25,0 %**	**96 %**	1
liquid assets/receivables	33	%	**7,0 %**	**6,0 %**	**86 %**	5
liquid assets/advances	8	%	**7,0 %**	**6,0 %**	**86 %**	1
liquid assets/cash	9	%	**7,0 %**	**6,0 %**	**86 %**	1
OTHERS	9				**100 %**	
TOTAL	**1 040**				**87 %**	**131**

Table 9.2 shows that, looking only at economy, the saving potential associated with the resource *Personnel, monthly paid* is the largest.

9.4 Assessing the optimality of resource amount

When assessing the optimality of resource amounts, attention is paid on resource amounts which cause both variable and fixed costs. Key figures which measure the utilisation of resource amount are defined for each resource sort:

Personnel: The utilisation of personnel resources may be assessed by means of the utilisation of working time. *The utilisation of working time* shows the share of available working hours which is used in effective work and in identical events repeated on different days.

Energy: The utilisation of energy may be assessed on the basis of actual efficiency.

Current assets: The utilisation of current assets is traditionally measured by the *turnover rate*.

Fixed assets: The utilisation of fixed assets is traditionally measured by the *utilisation rate*. Note that the key figures defined by different methods must be made commensurable by using the same number of planned working hours in each case.

Liquid assets: The utilisation of liquid assets may be roughly assessed by the *liquid assets percentage*, for instance, by comparing the average liquid assets per type of assets to annual total sales:

$$\text{Liquid assets-\%} = \frac{\text{average liquid assets}}{\text{sales}} \qquad (37)$$

When assessing only the share of advance payments of liquid assets, the annual volume of purchases may serve as a basis for comparison.

Table 9.3 presents a summary of key figures associated with the assessment of resource utilisation.

Table 9.3 Key figures for resource utilisation.

resource	**key figure of utilisation**
personnel / monthly paid	use of working time
personnel / hourly paid	use of working time
energy	efficiency rate
current assets	turn over
fixed assets	utilisation rate
liquid assets	liquid assets -%

Single key figures do not describe the potential associated with resource utilisation. A 100-% efficiency rate is not realistic, nor always a turnover of 30. The potential linked to utilisation may be examined by assessing, by means of comparison, the attainable optimal rates for the utilisation key figure *Optimal resource utilisation*. *Optimality of resource utilisation* is determined according to Table 9.4., from actual practices and attainable optimal practices (Column I+ shows resource sorts for which the inverse of the key figure is used). These key figures are used to assess, for each resource, the gap to optimal practice. In this context no attention is paid to the appropriateness of resources and the corresponding practices, but only to the resource amounts and their levels of utilisation.

Table 9.4 Optimalities of resource amounts. The values of key figures given in the table are not based on actual data.

A	B	I	I+	J	K	L	M
						= J / K (att. I+)	= (1-L) x B
RESOURCE	**Actual resource cost**	**Measure of utilisation**		**Actual resource utilisation**	**Optimal resource utilisation**	**Optimality of resource utilisation**	**Saving potential based on utilisation**
personnel, monthly paid	210	use of working time		**0,800**	**0,900**	**89 %**	23
personnel, hourly paid	240	use of working time		**0,800**	**0,850**	**94 %**	14
energy	33	useful energy		**0,700**	**0,900**	**78 %**	7
current assets/materials	16	turnover		**4,000**	**6,000**	**67 %**	5
current assets/WIP	25	turnover		**5,000**	**8,000**	**63 %**	9
current ass./finished prod.	60	turnover		**5,000**	**9,000**	**56 %**	27
fixed assets/machines	160	utilisation rate		**0,600**	**0,850**	**71 %**	47
fixed assets/ADP	85	utilisation rate		**0,500**	**0,700**	**71 %**	24
fixed assets/buildings	135	utilisation rate		**0,570**	**0,900**	**63 %**	50
other fixed assets	17	utilisation rate		**0,700**	**0,800**	**88 %**	2
liquid assets/receivables	33	receivables %	1	**1,9 %**	**1,0 %**	**53 %**	16
liquid assets/advances	8	advances %	1	**1,3 %**	**0,5 %**	**40 %**	5
liquid assets/cash	9	cash %	1	**0,5 %**	**0,3 %**	**64 %**	3
OTHERS	9					**100 %**	
TOTAL	**1 040**					**78 %**	**233**

Table 9.4 shows that, examined on the basis of utilisation of resource amount alone, the saving potential linked to the resource sort *Fixed assets / buildings* is the largest. When resource amounts are optimised separately for each resource it must be noted that the primary aim is not to increase resource use but to adjust the existing resource amount to its consumption.

It should be remembered here that maximising the efficiency rate of machines, for example, contains the risk of partial optimisation. As was noted in Chapter 8, the productivity of mechanical work is affected by the combination of the machine's efficiency rate and method efficiency. In certain situations poor method efficiency may actually contribute to a high efficiency rate. Achieving a maximum efficiency rate for key machines may not necessarily be optimal for the entire order–delivery process. High efficiency rates cause vulnerability to variability and may thus increase lead times.

9.5 Identifying development objects

When identifying the development objects, the first step is to identify the resource (sort) with the largest saving potential. After that, actual development actions are derived from the problems linked to the resource sort.

9.5.1 Selecting resources to be examined

In selecting resources to be examined, primary attention is paid to resource sorts which are most significant in terms of cost, most uneconomical and most poorly utilised, as shown in Table 9.5. Table 9.5 combines the analyses presented in Tables 9.1, 9.2 and 9.4, and shows a calculated optimality of resource cost for each resource, as well as the corresponding saving potential.

Table 9.5 Identification of resources to be examined in order to optimise resource costs.

A **RESOURCE**	B **Actual resource cost**	G **Optimality of resource economy**	L **Optimality of resource utilisation**	N = B x G x L **Optimal resource cost**	O = G x L **Optimality of resource cost**	P = B - N **Saving potential of resource cost**
personnel, monthly paid	210	87 %	89 %	**162**	**77 %**	**48**
personnel, hourly paid	240	93 %	94 %	**209**	**87 %**	**31**
energy	33	61 %	78 %	**16**	**47 %**	**17**
current assets/materials	16	70 %	67 %	**7**	**47 %**	**9**
current assets/WIP	25	72 %	63 %	**11**	**45 %**	**14**
current ass./finished prod.	60	75 %	56 %	**25**	**42 %**	**35**
fixed assets/machines	160	85 %	71 %	**96**	**60 %**	**64**
fixed assets/ADP	85	97 %	71 %	**59**	**70 %**	**26**
fixed assets/buildings	135	91 %	63 %	**78**	**58 %**	**57**
other fixed assets	17	96 %	88 %	**14**	**84 %**	**3**
liquid assets/receivables	33	86 %	53 %	**15**	**45 %**	**18**
liquid assets/advances	8	86 %	40 %	**3**	**34 %**	**5**
liquid assets/cash	9	86 %	64 %	**5**	**55 %**	**4**
OTHERS	9	100 %	100 %	**9**	**100 %**	
TOTAL	**1 040**	**87 %**	**78 %**	**709**	**68 %**	**331**

When considering the optimalities of both resource economy and utilisation, Table 9.5 indicates that the saving potential with the greatest combined effect is associated with the resource sort *Fixed assets / machines*.

The calculated total saving potential shown in Table 9.5 is naturally smaller than the sum of saving potentials calculated in Tables 9.2 and 9.4, because of the multiplier effects of elements included in a saving potential. Table 9.5 also shows that on the company level, the adjustment of resource amounts is a bigger problem than resource economy (optimality of resource utilisation [78%] < optimality of resource economy [87%]).

9.5.2 Determining development actions

The identification of development actions to optimise resource costs may be supported by a block diagram, as presented in Figure 9.1.

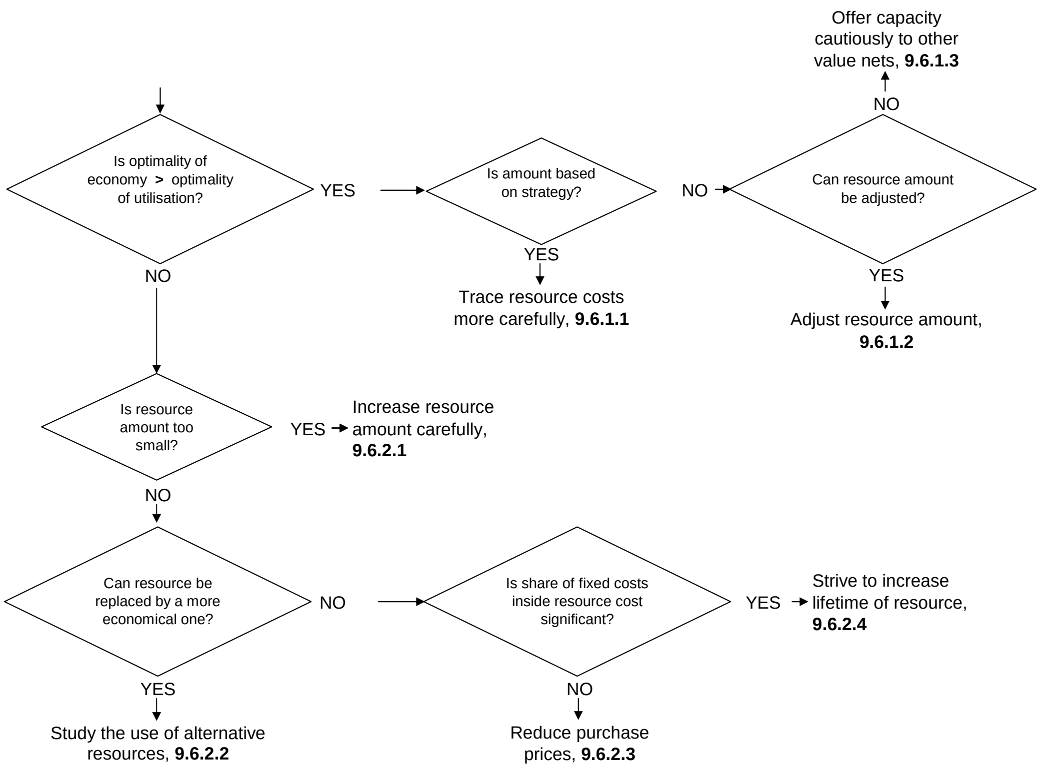


Figure 9.1 Identification of actions to optimise resource costs.

The numbering next to the optimisation actions shown in Figure 9.1 refers to the sections below.

9.6 Optimising resource costs

In this context a number of development actions are presented to optimise resource costs. The attempt is to affect resource costs by focusing attention on resource utilisation and resource economy.

9.6.1 Optimising resource amount

The traditional approach to capacity dimensioning was based on dimensioning according to demand. Throughput times were not a point of interest; rather, the aim was to find the capacity which enabled the lowest cost. The modern approach to capacity dimensioning takes into account the fact that increasing efficiency rates increase congestion and that throughput times and correspondence are linked to decisions concerning capacity. The problem is to find the fixed estimate which offers the best assembly, to minimise the cost in achieving performance (Factory Physics, 2001).

9.6.1.1 Specifying resource cost allocation

The starting-point in this study is to include the costs caused by existing capacity in the examination of resource costs. However, all resource requirements are not necessarily caused by immediate capacity requirements. When examining total resource amounts, the reason for the existence of extra capacity must be understood. The causes of overbuilding manufacturing capacity may include the following (Factory Physics, 2001):

Capacity as Strategic Weapon
- supply can create demand ("invest and grow")
- preemptive weapon (prevents smaller competitors from adding capacity)

Location Decisions
- move into geographic market
- transportation costs
- attractive locales to recruit talent

Technological Factors
- adding capacity in large increments
- economies of scale
- long lead times in adding capacity
- minimum efficient scale increasing over time
- changes in production technology

Structural Factors
- significant exit barriers
- motivation from suppliers
- building credibility with customers
- integrated competitors
- effects of capacity share on market share
- effects of age/type of capacity on demand

Managerial Factors
- management background and industry experience
- attitude towards different types of risks

Competitive Factors
- large number of companies
- lack of credible market leaders
- entry of new competitors
- advantages of being an early mover
- competing on quality/responsiveness requires capacity cushion

Information Flow Factors
- inflation of future expectations
- divergent assumptions or perceptions
- breakdown of market signaling
- structural change
- financial community pressures

Governmental Factors
- perverse tax incentives
- desire for indigenous industry
- pressure to increase / maintain employment

Since the cost caused by extra resources is a genuine cost which needs to be met, it is important from the overall point of view to focus attention on cutting it. In order that the company can draw the right conclusions, the cost caused by the extra capacity must be properly traced to the right object (the cause of building the extra capacity), according to the principle that costs are borne by those who cause them.

9.6.1.2 Adjusting resource amount

Resources have a different adjustability. Some resources require a long-term commitment, yet no income or cost savings can be expected if it proves that the resource amount has to be adjusted or a decision is taken to abandon it completely. In terms of cost, resources may be divided in to three categories of *adjustability*:

- *Resources with short-term adjustability*: the cost caused by these is traditionally regarded as variable cost.
- *Resources with long-term adjustability* cause so-called fixed costs, which may be influenced over a longer period of time. These include buildings and certain monthly-paid personnel.
- *Unadjustable resources*: the cost caused by these mostly consists of work already completed, with no value when separated from the overall whole. These include customised computer systems and customised production machinery.

Personnel resources

Hourly-paid personnel and a significant number of monthly-paid personnel have traditionally been regarded as a resource with short-term adjustability. Flexible working hours may reduce the need for a back-and-forth adjustment of personnel resources in connection with strong seasonal fluctuations, for instance.

Current assets

The volume of current assets may be affected by such things as standardisation and modular product architectures, by continuous-flow production, by decreasing the lead time of production and by decreasing batch sizes.

In developing manufacturing activity, one of the grounds for investment in automation may be the shortening of product throughput times and decreasing of work in progress; in other words, an increase in fixed assets is designed to decrease current assets. An important point to note in connection with such investment decisions is that the savings realised by tied-up current assets have to be larger than the actual increase of fixed assets. Another thing to note is the different *adjustability* of different resource sorts.

Fixed assets

In most cases, fixed assets consists of *resources with a long-term adjustability* or *unadjustable resources*. In practice, the adjustment of fixed assets often means selling them or otherwise giving them up. In some cases, the cost is due to the fact that the amount of fixed assets cannot be adjusted, and the cost due to extra capacity must be treated as a separate *unadjustability cost*.

Liquid assets

The share of liquid assets (advance payments and sales receivables) of the turnover may be affected by such things as the terms of payment of purchasing and sales invoices and by various risk analyses related to sales receivables.

9.6.1.3 Offering capacity to other companies

If a company has extra capacity, the corresponding resource may be offered to other companies / value nets. This option must be regarded with a certain reservation because of the risk of partial optimisation involved. As was noted before, a match between the operational and resource structures is worth striving for. If a resource is offered to other companies / value nets, the match between structures may be significantly weakened, as may the manageability of the system. The weakened manageability and the cost caused by this may be manifested in multiple and surprising ways. In general it may be said that a capacity reserve guarantees short throughputs and provides flexibility in arrangements. Sharing the resource may cause queues and longer throughputs.

If a company's fixed costs are high, its cost position is affected by the level of utilisation of essential resources, the utilisation rate. According to Porter, the true factor causing cost is the fluctuation of this rate during an economic cycle, not the rate achieved during any given point in time. Companies are often misled into sharing resources because they have extra capacity in an operation. However, if the sharing of resources is not based on economies of scale or learning or does not improve the long-term utilisation rate of capacity, sharing usually brings disadvantages due to costs. The correct solution would be to decrease capacity instead of sharing it. (Porter, 1985).

9.6.2 Optimising resource economy

9.6.2.1 Increasing resource amount

When the amount of needed capacity is above a defined standard, the increase in the total cost of certain resources is more than linear. As an example, with a sudden increase in personnel demand, it may be necessary to work overtime or resort to other concessions, in which case the actual unit cost of the resource will be higher than before. In this case the appropriateness of a more permanent increase of the resource amount must be examined. It must also be noted that in a situation of rapid growth, most of the employees' work input may be consumed in training new personnel.

9.6.2.2 Changing a resource

If the actual unit cost of a resource is found to be high, it is naturally appropriate to consider whether it could be changed for a more advantageous one. The capability which different resources have of producing added value may be assessed by such methods as *value analysis*.

If the amount of own resources can be adjusted in the short term, outsourcing can offer a possibility of decreasing resource unit cost. As mentioned in the beginning of this chapter, in this kind of situation attention must be paid to the commensurability of alternative resources.

9.6.2.3 Minimising the purchasing prices of resources

The starting-point of minimising the purchasing prices of resources is an awareness of the optimality of the current price level, for which *comparison* can give a good basis. When determining the capital cost of different resources it is simplest to apply the same average rate of interest for all tied-up capital.

9.6.2.4 Prolonging the life of a resource

Prolonging the life of current assets improves resource economy by increasing the divider of fixed capital cost. In this context, attention must be focused on optimising total cost, including maintenance cost, and on the continued appropriateness of the resource in spite of technology development.

10 OPTIMISATION OF SPEED

The aim of optimising the speed of the order–delivery process is to shorten the lead time of the order–delivery process. This chapter presents the approach developed within this study to optimise the speed of operation. The importance of speed as both a competitive and a operational success factor increased significantly during the 1990s. Customers expect delivery times to be short and reliable. The increasing of the speed of processes also improves their efficiency and manageability. The following presents advantages achieved with the increased speed of operation, by a comparison of slow and fast operations:

SLOW OPERATION	⟷	FAST OPERATION
long delivery times	⟷	short delivery times
high dependency of forecasts	⟷	low dependency of forecasts
poorly estimated	⟷	under control
low reliability of delivery	⟷	high reliability of delivery
large amount of current assets	⟷	small amount of current assets
plenty of changes	⟷	some changes
inefficient	⟷	efficient
supports partial optimisation	⟷	stress on overall entity
performance unknown	⟷	performance known
slow quality feedback	⟷	fast quality feedback

The chapter opens with the definition of the content of several concepts as they are understood in this study. The main focus of the chapter lies on the introduction of the analyses required for the identification of development objects. The chapter concludes with examples of development actions which increase the speed of the order–delivery process.

10.1 Concepts and key figures associated with speed

The concepts and key figures used in this study and not defined above are presented here.

Throughput time (product viewpoint) is the calendar time for a product to pass through the operation.

Lead time (operation viewpoint) is the calendar time used to complete the operation. The lead time of an operation is determined on the basis of the critical path formed by lower-level operations. The lead time of an operation may be defined by analysing the throughput times of single products.

Critical path is the chain formed by the interdependent basic operations whose lead time determines the lead time of the upper-level operation studied.

Cycle time (resource viewpoint) is the length of calendar time which the resource studied (machine) works with products.

Value adding working time is the total time used to process the product from basic resources in the operation studied.

Degree of utilisation describes the number of planned working hours. The maximum degree of utilisation is the number of working hours available.

Efficiency of time consumption of operation measures the share of value adding working time calculated from the lead time of the corresponding operation.

$$\textit{Efficiency of time consumption of operation} = \frac{\textit{value adding work time}}{\textit{lead time of operation}} \quad (38)$$

Bottleneck resource is a resource which constrains operation throughput. Queue time occurs before a bottleneck resource.

Delivery time (customer viewpoint) is the length of calendar time which elapses from the customer impulse (such as an order or delivery call) to the moment when the product is delivered to customer as agreed.

10.1.1 Delays

In the MSDD model (Cochran et al., 2002) all the elements of time which the product spends in manufacturing without being processed are called *delays*. The factors which slow down an operation, or *delays*, are identified by a more detailed analysis of the throughput time. Similar models of throughput time have been presented by Factory Physics (2001), Bartezzaghi et al. (1994) and Wacker (1996), to name a few. Figure 10.1 shows a summary of the throughput time models studied here. The definitions of time types (lead time, throughput time, cycle time) presented in these models are not comparable with the ones used in this study.

	Factory Physics		**Bartezzaghi et. al.**		**MSDD**		**Wacker**
	move time				tranporta-tion delay		Move Time
+	queue time	+	queue time (Q)	+	process delay	+	Queue Time
+	setup time	+	set-up time (SU)	+	run size delay	+	Set-up Time
						+	Rework Time
+	process time	+	run time (R)	+	process time	+	Run Time
+	wait-to-(un)batch time	+	wait-to-move time (WTM)	+	lot delay	+	Stockout Time
+	wait-to-match time	+	synchro time (SY)	+	systematic operational delays		
+	wait-in-batch time	+	net buffer time (NB)				
		+	problem solving time (PS)			+	Down Time
=	**cycle time**	**=**	**lead time**	**=**	**throughput time**	**=**	**Manufac-turing Lead Time**

Figure 10.1 Throughput time models presented in literature.

As a summary of the throughput time models presented, in this study the throughput time per product of an operation inside the order–delivery process is divided into value adding throughput time and the following de-lays:

	idle time	
+	wait-to-move time	
+	move time	
+	queue time	
+	synchro time	
+	setup time	
+	**value adding throughput time**	
+	buffer time	
+	disturbance time	
=	**THROUGHPUT TIME**	(39)

Idle time is time comparable to calendar time, during which the operation is not being implemented; during idle time the resources consumed in the operation are not designed to work within the operation, i.e., nothing happens.

Wait-to-move time is understood as the time spent in complementing a moved or complemented batch.

Move time is the time spent in moving products inside an operation.

Queue time is created when a product queues for processing by the resource which implements the operation (while the resource is otherwise occupied). Queue time does not include setup time, which is defined separately.

Synchro time is caused when the product is waiting. The operation cannot be implemented because all the INPUT products needed in the implementation are not available at the time desired.

Setup time, in this context, is the part of throughput time during which a resource which processes the product is being set up.

Value adding throughput time is the part of throughput time during which the product is processed.

Buffer time is the time spent by the product in safety, surplus and decoupling buffers (does not include synchro time).

Disturbance time includes occasional periods for problem solving, maintenance and product repair.

The same delays can be used to analyse the lead time. Since the object of study is the throughput time (lead time), only the time elements which affect the critical path will be considered as delays.

10.2 Determining the efficiency of time consumption per activity

In this study, the activities selected for development in the context of optimisation of speed are identified on the basis of the development potentials found in the efficiencies of time consumption per activity. As regards the composition of the lead time, all activities are of equal value. By estimating the development potential of each activity with the help of the efficiency of time consumption it is possible to make the different activities commensurable. The main product-based throughput times are analysed at this stage.

10.2.1 Analysing main throughput times

The analysis of lead time applies the general activity-based description of operation presented in Chapter 2.5.2. In the order–delivery process, the lead time begins with the customer order and ends with the delivery to customer. In practice, the realisation of activities is overlapping, which is why the process lead time is not the sum of the lead times of activities inside the process. The process lead time (the main throughput times) is determined by the critical path inside the process, which is illustrated by the diagram in Figure 10.2.

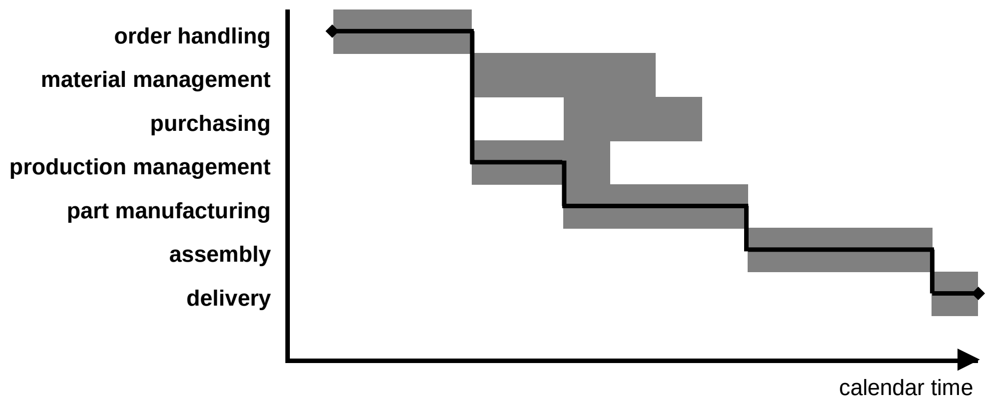


Figure 10.2 Example of the composition of main throughput times.

In this context, the delays "between" activities are included in the activities. If the unambiguous definition of when activities begin and end is problematic, this shows a poor overall control of the process. In the context of analysing the lead time it should be noted that the definition of the critical path is influenced by changes. When process lead time has been cut down by actions such as those presented in this report, the critical path is likely to have changed and will have to be re-defined.

It must be noted that main throughput times can vary according to the product mix under production. The definition of stable lead time requires a stabilised process and corresponding circumstances.

The shares of each activity inside the critical path which determines the main throughput times are presented in Table 10.1.

Table 10.1 Example of the share of each activity inside the critical path determining the main throughput times.

A	B	C
ACTIVITY	**Throughput time inside critical path / days**	**Share of total throughput time**
order processing	**3**	21,4 %
material management		
purchasing		
production management	**2**	14,3 %
part manufacturing	**4**	28,6 %
assembly	**4**	28,6 %
delivery	**1**	7,1 %
TOTAL	**14**	

10.2.2 Determining the value adding working time per activity

In this context, the working time which adds value to the products under study for each activity is determined (Column D in Table 10.2). Note that only the section of value adding working time is included which has an impact on the critical path: how much will the product be processed, in terms of working time, before the next operation along the critical path can be started. Column E in Table 10.2 shows the share of total value adding working time of each activity inside the critical path.

Table 10.2 Example of actual value adding working times per activity.

A ACTIVITY	D Actual value adding work time / hours	E Share of total value addinng work time of process
order processing	**8**	5,6 %
material management		
purchasing		
production management	**8**	5,6 %
part manufacturing	**24**	16,7 %
assembly	**96**	66,7 %
delivery	**8**	5,6 %
TOTAL	**144**	

10.2.2.1 Eliminating non-value-added activities

If, in the context of determining the value adding working times per activity, activities which do not add value to the product have been identified, they must be examined separately using the principles described under 8.2.1.1.

10.2.3 Determining the efficiency of time consumption

When determining the efficiency of the utilisation of throughput times, calendar time is treated in the same way as the basic resources for processing the product. The main attention is focused on the efficiency of use of calendar time for value adding work. The example in table 10.3 is an analysis of the process presented in Figure 10.2.

Table 10.3 Example of actual efficiencies of time consumption per activity.

A ACTIVITY	B Throughput time inside critical path / days	D Actual value adding work time / hours	F = D / (B x 24) Actual efficiency of time consumption
order processing	3	8	**11 %**
material management			
purchasing			
production management	2	8	**17 %**
part manufacturing	4	24	**25 %**
assembly	4	96	**100 %**
delivery	1	8	**33 %**
TOTAL	**14**	**144**	**43 %**

Column F shows the actual efficiency of the utilisation of main throughput times or, in other words, the share of value adding working time calculated from the main throughput times which determine the critical path.

10.3 Identifying activities to be developed

This study focuses primarily on development actions which are implemented on the activity level. The shortening of lead time is started by calling into question the existence of activities which include non-value adding time (see 10.2.2.1). Since the development potential involved in the mutual synchronisation of activities which determine the critical path of the process cannot be identified in analyses internal to each activity, this must be dealt with separately before the internal analyses of activities. Ultimately, activities selected for development are identified by their potential for increasing the efficiency of time consumption.

10.3.1 Developing the synchronisation of activities

Before the optimisation of the efficiency of time consumption, the optimality of value adding working times inside the critical path must be examined, and the optimal share of value adding working time needed inside the critical path must be estimated.

In this context it is necessary to identify the synchro times between activities eventually included in the process lead time: Does an activity inside the critical path have to wait for its INPUT products from another activity inside the same process? Could the waiting times be shortened by increasing the overlap of activities? Could, for example, the actual batch size of the preceding activity be changed so that the following stage could be started earlier? It must be ensured that in each activity, the share corresponding to the critical path only carries out the absolutely necessary (optimal) amount of value adding work. Column E in Table 10.4 presents estimates of *optimal value adding working times* for different activities.

Table 10.4 Example of determined optimal value adding working times and corresponding theoretical efficiencies of time consumption.

A **ACTIVITY**	B **Throughput time inside critical path / days**	D **Actual value adding work time / hours**	E **Optimal value adding work time / hours**	F = D / (B x 24) **Actual efficiency of time consumption**	G = E / (B x 24) **Theoretical efficiency of time consumption**
order processing	3	8	**5**	11 %	**7 %**
material management					
purchasing					
production management	2	8	**6**	17 %	**13 %**
part manufacturing	4	24	**20**	25 %	**21 %**
assembly	4	96	**96**	100 %	**100 %**
delivery	1	8	**8**	33 %	**33 %**
TOTAL	**14**	**144**	**135**	**43 %**	**40 %**

Column G in Table 10.4 also shows the *theoretical efficiency of time consumption* corresponding to the optimal value adding working times. Since optimal value adding working times are shorter than (or equal to) actual working times, the theoretical efficiency of time consumption is smaller than (or equal to) the actual efficiency of time consumption.

10.3.2 Determining the optimal efficiency of time consumption per activity

In this context, the *targeted optimal efficiency of time consumption* is determined for each activity. This is affected by the best practices achieved in the value net studied, by comparison data from similar practices achieved in other value nets, and the level of excellence aimed at by the value net or individual company. If speed of operation is emphasised as an operational success factor, there should exist obvious areas of capability in which a particularly good speed is achieved. In Table 10.5, the *targeted optimal efficiency of time consumption* (Column H) is used to determine the *targeted optimal throughput times* for each activity inside the critical path (Column I)

Table 10.5 Example of targeted optimal efficiency of time consumption and corresponding throughput times.

A ACTIVITY	B Throughput time inside critical path / days	E Optimal value adding work time / hours	F Actual efficiency of time consumption	G Theoretical efficiency of time consumption	H Targeted optimal efficiency of time consumption	I = E / 24 / H Targeted optimal throughput time
order processing	3	5	11 %	7 %	**33 %** →	**0,6**
material management					→	
purchasing					→	
production management	2	6	17 %	13 %	**33 %** →	**0,8**
part manufacturing	4	20	25 %	21 %	**66 %** →	**1,3**
assembly	4	96	100 %	100 %	**100 %** →	**4,0**
delivery	1	8	33 %	33 %	**33 %** →	**1,0**
					→	
					→	
					→	
TOTAL	**14**	**135**	**43 %**	**40 %**	**74 %**	**7,6**

Even at this stage it should be noted that the actual and targeted efficiencies of time consumption are significantly affected by the capacity and degree of utilisation of the key resources for each operation. If several resources cannot be used simultaneously, the targeted optimal efficiency of time consumption in a one-shift system can be 33.33% at best.

10.3.3 Determining the level of development

In this context, the adequacy of the development potential is assessed. Table 10.5 defines the *targeted optimal lead time* per activity on the basis of the *targeted optimal efficiency of time consumption*. If the targeted optimal lead time of the whole order–delivery process meets the goals set, the optimisation of process speed may be continued. If the targeted optimal lead time is found to be too long, process reengineering must be started. If the actual lead time is sufficiently close to the targeted lead time, attention may be transferred on other operational success factors.

10.3.4 Selecting the activities for development

In line with figure 6.2, the activities selected for development are those which take up a significant share of total process lead time and which contain a large potential for improving the efficiency of time consumption. This means activities with the greatest potential for shortening the lead time.

Table 10.6 presents a calculated estimate of the development potential contained by single activities. Column J shows the actual wasted throughput time per activity, or the potential for decreasing throughput time. Column K contains the corresponding ratio describing the waste of throughput time.

Table 10.6 Selection of activities to be developed to increase process speed.

A **ACTIVITY**	B **Throughput time inside critical path / days**	E **Optimal value adding work time / hours**	H **Targeted optimal efficiency of time consumption**	I = E / 24 / H **Targeted optimal throughput time**	J = B - I **Potential to decrease throughput time**	K = J / B **Wasted share of throughput time**
order processing	3,0	5	33 %	0,6	**2,4**	**79 %**
material management						
purchasing						
production management	2,0	6	33 %	0,8	**1,2**	**62 %**
part manufacturing	4,0	20	66 %	1,3	**2,7**	**68 %**
assembly	4,0	96	100 %	4,0		
delivery	1,0	8	33 %	1,0		
TOTAL	**14,0**	**135**	74 %	**7,6**	**6,4**	**45 %**

On the basis of Table 10.6, the primary actions for shortening the lead time should be focused on the activity *Part manufacturing*, since it contains the greatest potential for this. Similarly, *Order processing* should be examined in more detail.

10.4 Increasing the speed of an activity

On the activity level, the measures to shorten the lead time are based on eliminating ineffective tasks and on shortening delays and value adding lead time.

Analysing the lead time of an activity

The lead time of an activity may be divided into delay categories established by means of a continuous time consumption study, for example. Figure 10.4 shows and example of the relative shares of delays in the lead time of the activity *Part manufacturing*.

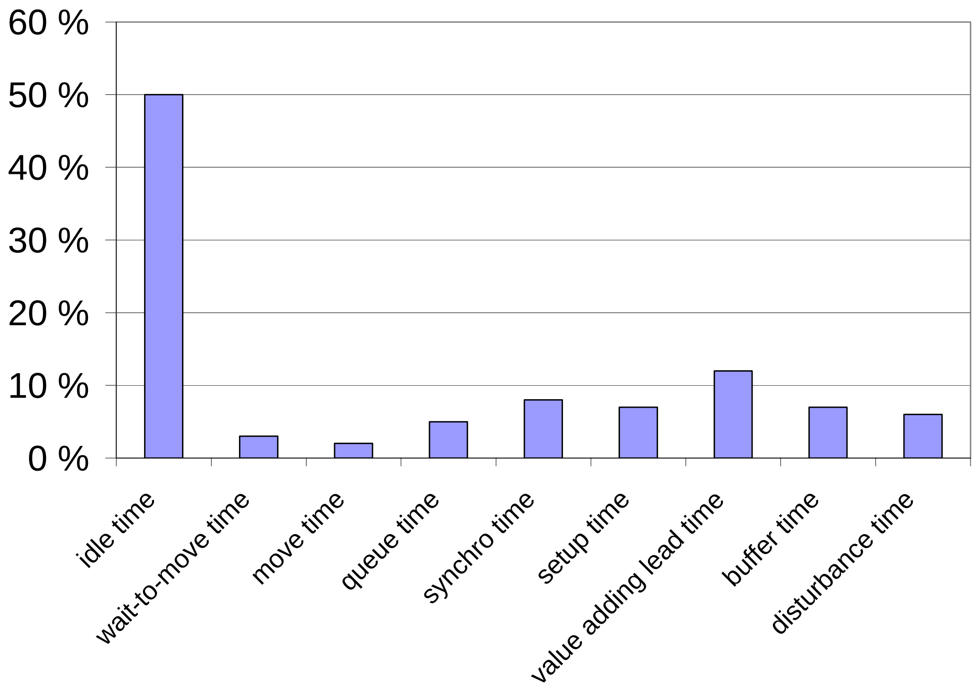


Figure 10.4 Example of the breakdown of lead time for the activity *Part manufacturing*.

Traditionally, time consumption studies carried out in connection with time-and-motion studies have concentrated on mapping the time consumption of a resource (person). At the first stage, the time consumption studies carried out in this context must identify the critical path inside an activity, which may be defined by analysing the throughput times of single products. An analysis of the fictional example in Figure 10.4 shows that development actions should be primarily focused on shortening idle times. If the utilisation degrees of basic resources cannot be improved, the next objects to be examined are the synchro, setup and buffer times.

The following contains a sample list of measures to shorten *delays*, or time elements which slow down an activity.

10.4.1 Elimination of unnecessary tasks

When analysing the breakdown of activity lead time, it is necessary to identify tasks which do not include value adding time. The elimination of ineffective tasks was already noted under 8.4.1.

10.4.2 Shortening idle times

Idle time may be shortened by increasing the planned working hours of the key resources of the activity, i.e., by improving the utilisation degree of resources. The degree of utilisation may be improved by, for instance, working two shifts instead of one.

10.4.3 Shortening wait-to-move times

In the production of physical goods wait-to-move times are created when the size of the batch moved is greater than one. Primary development actions are naturally focused on the decreasing of moved batch size. When determining the size of the batch moved, it must be noted that its size need not be the same as that of a manufacturing batch. As regards physical products, a resource structure which corresponds to the operation structure, a layout which conforms to the material flow (line, cell), and the eventual automation of the moving of material enable the decreasing of batches moved. In striving for a one-piece flow, as the manufacturing batches become smaller, also the batches moved and correspondingly the wait-to-move times are decreased. The number of moves may be decreased by combining successive operations. In shortening wait-to-move and move time, the risk of partial optimisation must be avoided. Decreasing the size of batch moved increases the number of moves. The critical path determining the lead time is determined on the basis of wait-to-move times, move times (interdependence of successive moves) and the manufacturing times of each operation.

As regards information products, the wait-to-move times are concretised during such phases as the definition of basic product data: must the critical data for an item wait until the last detail has been defined, before the basic data needed inside the critical path can be reworked by the subsequent phases.

10.4.4 Shortening move times

The primary goal is to minimise the need for moves. Moves can be reduced using multi-skilled resources, for example, so that one resource can realise many operations.

Move times may be shortened by speeding up the move and/or shortening the distance moved. Moves may be speeded up by faster equipment: conveyors, trucks, automated equipment, data connections, etc. If the speed of data transmission is high enough, the distance of transmission is of no significance. Distances may be shortened by reorganising resources: by implementing new machine layouts or personnel organisation. In both cases, modifying the resource structures to correspond to operation structures, reorganising resources according to the process, will contribute to shorter move times; for machines, layouts should correspond to material flows, while personnel should work in teams. Networking and outsourcing may increase the number of moves, thus possibly affecting move times adversely.

10.4.5 Shortening queue times

Queues are created before the bottleneck resource of an activity. According to the TOC philosophy, the throughput of a bottleneck resource determines the throughput of the entire activity. Lapinleimu (1980) has presented the links between throughput time, work start-up time and the volume of work in process, as shown in Figure 10.5. The early start-up of work may be assumed to include the assumption of long queue times.

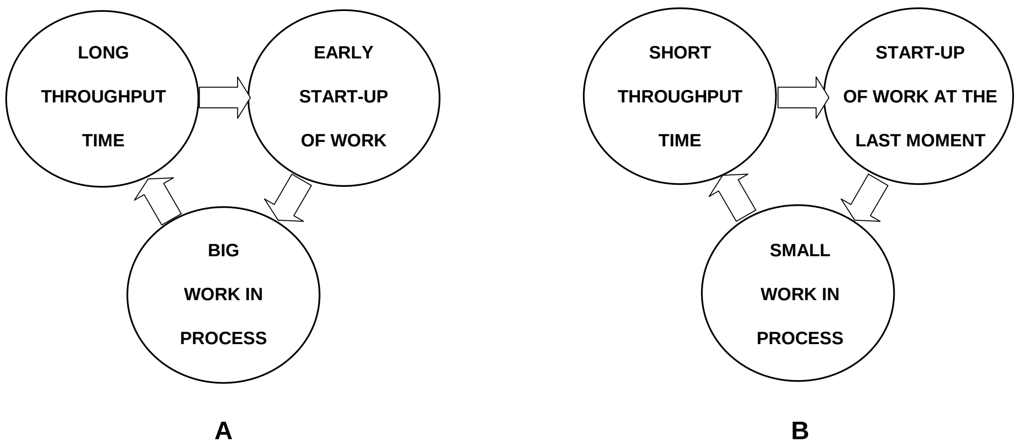


Figure 10.5 Link between work in process and throughput time. Vicious circle A of slow throughput and Vicious circle B of rapid throughput. Based on Lapinleimu (1980).

In this context, work in process does not only include unfinished physical products, but also services and information products in process. The vicious circles shown in Figure 10.5 appear just as easily on the desk as in the workshop. Following is an examination of decreasing batch sizes and developing control as means of decreasing the volume of work in process.

Decreasing batch sizes

The concept of batch size is traditionally associated with physical products. As regards information products, the concept may, for example, be linked to computer batch runs. For service products, batch size might be associated with training to be delivered.

Goldratt has simplified the link between batch sizes and throughput times. Halving batch sizes will halve the value adding throughput time of batch, corresponding queue and waiting times and the corresponding total throughput time. According to Goldratt, the benefits of decreasing throughput are greater than the decreasing costs of decreasing setup work. (Goldratt & Cox, 1987)

According to Lapinleimu (2000) one of the development features of batch production is the elimination of batch-specific work (setups) between batches. Batch production will then become continuous in character, so that batch and bulk production combine to form the principle of "one piece flow". This flexible continuous production is regarded as the desired form of production of the ideal factory.

Developing control

The starting-point of developing control is to internalise the goals set for the overall operation and to identify the objects which should appropriately be controlled in order to reach the goals. From the viewpoint of goal attainment, all work is not of equal value, so that it is important to distinguish the essential from the inessential in developing control. In controlling the progress of an operation the essential factor is the control of variability. Decreasing variability always leads to a better control. The development of control may be divided roughly into developing the external control of an operation and developing its internal control. If the baseline and actual data used by the external control of an operation are not updated continuously, variability cannot be controlled and the controlling capability of the control system disappears. The implementation of internal control in itself requires a degree of stability. The means of developing the external control of an operation may include the following:

- precise controlling of the bottleneck resources,
- controlling the order of work,
- precise controlling of the volume accepted at the first stage of the operation chain,
- decreasing queue buildup by evening out the processing times of products worked on simultaneously inside the activity, by means of differing batch sizes,
- American literature (e.g., Cochran et al., 2002, Rother et al., 1999) emphasise the takt time of production which is based on customer need, and the need to plan production according to this.

10.4.6 Shortening synchro times

Synchro times are caused by long internal and external delivery times and the lack of confidence between activities, caused by poor internal reliability of delivery. Long delivery times "just in case" lead to slow processes and contribute to a low reliability of delivery.

Removing synchro times requires that the agreed rules are honoured by the resources in the value net. There must be a joint, consistent effort to achieve the positive circle described in Figure 10.7. Every actor involved in the process must focus on serving their internal customer so that the customer faces no uncertainty. Uncertainty and lack of confidence lead to doing things just in case, which do not add value and contribute to longer lead times.

Shortening external delivery times

Following is a list of measures to shorten the delivery times of external INPUT products:

- increase the control of INPUT products inside the critical path,
- minimise the time buffers of items inside the critical path,
- maintain a storage of items with long delivery times,
- shorten the delivery times of components by developing the suppliers' operation,
- decrease uncertainty by improving forecasts,
- decrease the supplier's need for anticipation by a continuous specification of orders,
- assess suppliers and selecting competent ones,
- decrease the number of items to be controlled, by means of such methods as *baskets or sets,*
- make use of IT to make sure that the information concerning demand is available to the whole value net in the same form and in real time,
- treat external and internal suppliers in an uniform manner,
- increase the precision of control, harmonising in-house and supplier practices,
- analyse delivery times together with the supplier: what is the time spent on?

Shortening internal delivery times

Following is a list of measures for shortening the delivery times of internal INPUT products:

- increase the simultaneity of operations (overlapping affects lead times if overlapping operations are inside the critical path),
- increase the mutual synchronisation of operations by increasing the precision of control,
- decrease the effect of batch sizes,
- enable internal control by organising resources according to the operation structure,

- link autonomous (independent) operations into a "line",
- in a line solution, place the slowest resource at the beginning,
- develop the methods of communication between operations,
- increase the precision of control: prioritisation of scheduling and resource utilisation,
- increase the understanding of interdependence between the lead times of different operations,
- develop learning: form an optimal work order on the basis of actual experience,
- improve the usability of customer data: make the information on customer behaviour possessed by operations closest to the customer interface available to all operations in the value net,
- disseminate order-specific product data stage by stage according to the critical path of the order–delivery process.

10.4.7 Shortening setup times

In shortening setup times, the principles of the SMED (Single-digit Minute Exchange of Die) method, presented by Shingo, may be used (Shingo, 1982, pp. 48–54):

- separate internal from external setup operations
- convert internal to external setup
- standardize function, not shape
- use functional clamps or eliminate fasteners altogether
- use intermediate jigs
- adopt parallel operations
- eliminate adjustments
- mechanisation

If the setting up of a numerically controlled machine (such as changing of fixtures) cannot be based on numerical control and change of programmes, the setups must be stored ready to use and the change must be so designed as to be as easy as possible (Lapinleimu, 1993).

If the shortening of setup times does not lead to the desired result, their share can also be decreased by work organisation. Work may be classified according to the setup need, and a cycle may be determined for the bottleneck resource which determines the work order. Between the successive tasks in the cycle, the setups must be achieved with as little work as possible. Since work organisation increases work in progress (and lead time), it contains an obvious risk of partial optimisation.

10.4.8 Shortening value adding lead time

The value adding lead time of an activity is shortened by increasing the throughput of its key resources. Throughput may be increased by using alternative resources and/or increasing the capacity of the key resources. Capacity may be increased by increasing the resource amount and/or improving the productivity of work carried out by the resources. The latter was discussed in Chapter 8. It should be noted that improving the productivity of key resources by increasing the utilisation rate will multiply the effects of congestion caused by variability. These effects are not linear.

Harmonising the resource and operation structures and product architectures

The focusing of resources on the realisation of a smaller product volume, the adaptation of resource structures in line with product architectures, brings clarity into the loading of resources and improves throughput. According to Skinner, the concept of the focused factory (Skinner, 1992) is as true as it was 30 years ago. Skinner cautioned manufacturers to focus their competitive resources to obtain productivity improvements. The increased complexity of most manufacturing organisations has made this axiom of manufacturing even more essential today. The key is to reduce complexity and focus the critical organisation resources around competitive requirements.

10.4.9 Shortening buffer times

The operational variability which decreases performance may be eliminated by using buffers. Buffer times are affected primarily by stabilising operation, by shortening operational variability, as described in Chapter 7.

10.4.10 Shortening disturbance times

The decreasing of disturbances was discussed in Chapter 7 in connection with the stabilisation of operation. Recovery from disturbances may be affected by the following:

- anticipation,
- identification and
- solution of disturbances by standardised procedures.

10.5 Shortening value adding time

Value adding time may be shortened by means of the actions presented in Chapter 8 to improve operation.

The shortening of value adding time is important for the efficiency and economy of operation. One should not be mislead by the fact that shortening value adding time weakens the value of the key figure *Efficiency of time consumption*. It must be remembered that this key figure is used here only to identify the activities selected for development, not in order to evaluate performance. Process performance in terms of the operational success factor *Speed* is evaluated by the key figure *Process lead time*.

PART IV:

PRACTICAL VALIDATION

11 EMPIRICAL RESULTS

This chapter aims at verifying the practical applicability of the method developed. The method was tested in three client companies. All companies were active in manufacturing technology industry, and all processes selected for study are customer-driven.

11.1 CASE STUDY 1

Company A designs investment goods for the carrier vehicle business and manufactures them serially. The product is based on standard components designed in-house and is always customised to the customer's needs. Since the company was under an obvious pressure to shorten the time of delivery to customer, the object of study selected was the *production ramp-up process* which occurs before the delivery process.

11.1.1 Objectives

The objective set was to halve the lead time of the production ramp-up process. The 182-day lead time, which was the baseline value, was to be cut to 90 days.

11.1.2 Modelling

The activity chain included in the production ramp-up process, the activity lead times and the corresponding process lead time are shown in Figure 11.1.

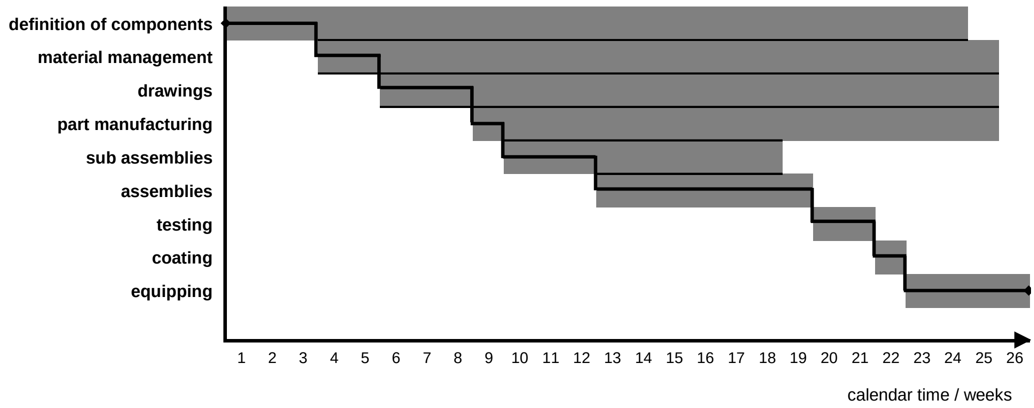


Figure 11.1 Activities in the production ramp-up process, the lead times of activities and the corresponding process lead time of Company A.

11.1.3 Stability of operation

Goals set for the process

There was no clear goal-setting for the start of serial production process which could have been led from higher-level goals, and no operational success factor had been prioritised. It was easy to note obvious inconsistencies in the sub-goals set for the process when compared with the goals set for the development project.

The goal-setting of the P*art manufacturing* activity emphasised efficiency and the high productivity of key resources. Part manufacturing emphasised functional organisation and batch production. As a corrective measure, the goal-setting of *Part manufacturing* was modified so that the its key goal was defined as the rapid and reliable service of the internal customer.

Product and process adaptabilities

Seen as a whole, the adaptability of the process studied corresponded to the adaptability of the product offered to the customer. The product was customised during the process to meet customer needs.

Process maturity

As a business, Company A was exceptionally advanced in improving the maturity of production operations. The explanation is that a strong input had been made in the production to standardise operations by instructions, as well as in the traditional productivity of work. Unfortunately, the same approach was not predominant in other operations. As regards production, the process maturity could have been graded as 4, if the key figures used for control had been updated more actively to correspond to the changes in general goal-setting. As regards other areas, process maturity would have corresponded to levels 1–2 of the model presented.

Process stability

The activities *Definition of Components* and *Drawings* did not control their own load and lead times. They were not able to meet their self-imposed throughput goals. As corrective measures, the control of these activities and the throughput goals set for each delivery project were made more explicit. The stabilisation of operation was also assisted by separating the operations *Product development*, *Offer planning* and *Application design* and the corresponding resources from each other.

The quality level of the information in product specifications could not be regarded as appropriate. The parts drawings which specify the product were not unambiguous: *Part manufacturing* needed to define its experience to include grinding, cambering, bevelling, etc. On the other hand, the question had to be asked whether Production provided Planning/design with sufficient feedback on the need to update and modify drawings.

The *Equipping* activity experienced the largest deviations from planned work and lead times. This was considered to be because of numerous disturbances in the preceding activities.

11.1.4 Performance measurements

The shares of each activity in the critical path determining the total throughput time of the production ramp-up process in Company A are presented in Table 11.1.

Table 11.1 The activities of the process studied in Company A and the shares of each activity of the total throughput time.

A	B	C
ACTIVITY	**Throughput time inside critical path / days**	**Share of total throughput time**
definition of components	**21**	11,5 %
material management	**14**	7,7 %
drawings	**21**	11,5 %
part manufacturing	**7**	3,8 %
sub assemblies	**21**	11,5 %
assemblies	**49**	26,9 %
testing	**14**	7,7 %
coating	**7**	3,8 %
equipping	**28**	15,4 %
TOTAL	**182**	

The work times per activity realised inside the critical path of the time for starting production are presented in Table 11.2.

Table 11.2 Value adding work time per activity inside the critical path of the process studied in Company A.

A	D	E
ACTIVITY	**Actual value adding work time / hours**	**Share of total value addinng work time of the process**
definition of components	**120**	6,4 %
material management	**80**	4,3 %
drawings	**120**	6,4 %
part manufacturing	**10**	0,5 %
sub assemblies	**300**	16,1 %
assemblies	**735**	39,3 %
testing	**40**	2,1 %
coating	**144**	7,7 %
equipping	**320**	17,1 %
TOTAL	**1 869**	

Table 11.3 contains a summary of Tables 11.1 and 11.2, presenting the actual efficiency of time consumption per activity.

Table 11.3 Actual efficiency of time consumption per activity in Company A.

A	B	D	F = D / (B x 24)
ACTIVITY	**Throughput time inside critical path / days**	**Actual value adding work time / hours**	**Actual efficiency of time consumption**
definition of components	21	120	**24 %**
material management	14	80	**24 %**
drawings	21	120	**24 %**
part manufacturing	7	10	**6 %**
sub assemblies	21	300	**60 %**
assemblies	49	735	**63 %**
testing	14	40	**12 %**
coating	7	144	**86 %**
equipping	28	320	**48 %**
TOTAL	**182**	**1 869**	**43 %**

The next aspect to study was the reduction of time used to synchronise activities. Column E in Table 11.4 shows the estimated optimal work times per activity, and Column G shows the estimated theoretical efficiency of time consumption corresponding to optimal work times.

Table 11.4 Optimal value adding work times and corresponding theoretical efficiency of time consumption in the process studied in Company A.

A ACTIVITY	B Throughput time inside critical path / days	D Actual value adding work time / hours	E Optimal value adding work time / hours	F = D / (B x 24) Actual efficiency of time consumption	G = E / (B x 24) Theoretical efficiency of time consumption
definition of components	21	120	**40**	24 %	**8 %**
material management	14	80	**80**	24 %	**24 %**
drawings	21	120	**40**	24 %	**8 %**
part manufacturing	7	10	**10**	6 %	**6 %**
sub assemblies	21	300	**180**	60 %	**36 %**
assemblies	49	735	**735**	63 %	**63 %**
testing	14	40	**40**	12 %	**12 %**
coating	7	144	**144**	86 %	**86 %**
equipping	28	320	**320**	48 %	**48 %**
TOTAL	**182**	**1 869**	**1 589**	**43 %**	**36 %**

In defining the targeted efficiency of time consumption, special attention was paid to the core competences identified in Company A. As can be seen in Table 11.5, the targeted optimal efficiencies of time consumption for Assembling and Sub-assembling clearly include a need for improvement. Table 11.5 shows the targeted optimal throughput times per activity, based on the defined targeted efficiencies of time consumption.

Table 11.5 Targeted optimal efficiency of time consumption and the corresponding targeted throughput times in Company A.

A ACTIVITY	B Throughput time inside critical path / days	E Optimal value adding work time / hours	F Actual efficiency of time consumption	G Theoretical efficiency of time consumption	H Targeted optimal efficiency of time consumption	I = E / 24 / H Targeted optimal throughput time
definition of components	21	40	24 %	8 %	**24 %** →	6,9
material management	14	80	24 %	24 %	**24 %** →	13,9
drawings	21	40	24 %	8 %	**30 %** →	5,6
part manufacturing	7	10	6 %	6 %	**36 %** →	1,2
sub assemblies	21	180	60 %	36 %	**150 %** →	5,0
assemblies	49	735	63 %	63 %	**150 %** →	20,4
testing	14	40	12 %	12 %	**12 %** →	13,9
coating	7	144	86 %	86 %	**90 %** →	6,7
equipping	28	320	48 %	48 %	**60 %** →	22,2
					→	
TOTAL	**182**	**1 589**	**43 %**	**36 %**	**69 %**	**95,7**

11.1.5 Level of development

The process lead time of 95,7 days which could be achieved through optimisation was determined to be short enough in comparison with the goals set, and it was decided to continue the optimisation.

11.1.6 Selection of activities for optimisation

On the basis of Table 11.6, the activity selected for primary development was *Assemblies*.

Table 11.6 The absolute and proportionate potentials for shortening throughput times examined in Company A.

A ACTIVITY	B Throughput time inside critical path / days	E Optimal value adding work time / hours	H Targeted optimal efficiency of time consumption	I = E / 24 / H Targeted optimal throughput time	J = B - I Potential to decrease throughput time	K = J / B Wasted share of throughput time
definition of components	21,0	40	24 % →	6,9	**14,1**	**67 %**
material management	14,0	80	24 % →	13,9	**0,1**	**1 %**
drawings	21,0	40	30 % →	5,6	**15,4**	**74 %**
part manufacturing	7,0	10	36 % →	1,2	**5,8**	**83 %**
sub assemblies	21,0	180	150 % →	5,0	**16,0**	**76 %**
assemblies	49,0	735	150 % →	20,4	**28,6**	**58 %**
testing	14,0	40	12 % →	13,9	**0,1**	**1 %**
coating	7,0	144	90 % →	6,7	**0,3**	**5 %**
equipping	28,0	320	60 % →	22,2	**5,8**	**21 %**
			→			
TOTAL	**182,0**	**1 589**	**69 %**	**95,7**	**86,3**	**47 %**

The primary goal was to cut the lead time of *Assemblies* from 49 days to about 20 working days.

11.1.7 Results of case study 1

The following describes the development actions defined to shorten the lead time of *Assemblies*, separately for each type of delay.

Non-value-added tasks: Decrease inspections: eliminate the welded butt joints of steel plates requiring inspection.

Idle time: Increase number of work shifts.

Value adding lead time: Increase throughput by increasing level of staffing per work station and number of parallel work stations. Shorten inspection time by increasing inspection capacity.

Synchro time: Decrease waiting times for parts. In Part manufacturing, identify critical-path components produced in-house and focus on them. Control Part manufacturing on the basis of sub-assemblies. Make an input in the service capability and reliability of sub-assemblies. Develop and stabilise the management of material flows from external sources.

Queue times: Decrease queue times for inspection by increasing inspection throughput.

Setup times: Decrease setup times by introducing standardised rotating gear to speed up the start of a new series.

11.1.8 Discussion of case study 1

The same development objects could perhaps have been identified through other methods or evaluations. The study and analysis of all activities in the process as equal from the viewpoint of lead time composition clearly assisted the entire organisation in becoming aware of the issue. The fact that the company operates in two localities had contributed to a less clear overall view.

The management of the company was convinced that the analyses had pointed to the correct development objects and actions.

11.2 CASE STUDY 2

Company B designs, manufactures and markets investment goods for the international market, with exports taking up some 90% of the total sales. The object of study selected was the delivery process of a product shared with a foreign partner company.

11.2.1 Objectives

The company's primary objective was to decrease the product cost created during the shared delivery process. It had been decided that cost saving would be approached by focusing simultaneously on the operational quality of the process and on the product construction. In this context the discussion is limited to operations not affected by changes in the product construction.

Determining the value added by the process was considered an unfamiliar approach by the company. The target efficiency for the shared delivery process was set at 1.5, more in the nature of an experiment than anything else.

11.2.2 Modelling

Company B has modelled its key processes in a quality manual documented electronically according to the ISO 9000:2000 standard. The operation of Company B is fully driven by customer orders. The products are mainly mass customised: the section of product responsible for the main function can be realised completely by means of the product architecture configured and the standardised modules. In addition to this, constructions specific to each order are customised for the product.

The activity chain contained by the delivery process shared with the partner is shown in Table 11.7.

11.2.3 Stability of operation

Goals set for the process

The goals set for the process could not be regarded as unambiguous in terms of developing operational activity. The goals were linked to the cost of the product achieved in the process and did not stress any of the operational success factors examined in this study. However, the company's strategic goal-setting was not reviewed in this context.

Product and process adaptabilities

Product adaptability was determined by the product component which required the highest volume of case-specific service. Although the basic function of the product was realised through modular entities, product adaptability was determined by the order-specific planning required by equipment.

The shared product was created at the partner's facilities. The operations needed by the joint product were clearly different from the operations required by the partner's own products. From the point of view of operations required, the differences between products created jointly were small.

The product and process adaptabilities could be said to correspond to each other: C process created C products.

Process maturity

The prevailing maturity level of the process studied was low. To create the product, one-off, undocumented, lower-level operations had to be implemented at least for the time being.

Process standardisation

Though the process maturity level was found to be low, the variation included in the realised working hours for joint products could be considered small. Thus, it was possible to determine average work and lead times with sufficiently small variation for the activities.

11.2.4 Performance measurements

To determine the operational efficiency of the order–delivery process, the added value created by the activities was determined (Table 11.7). The determination of added values was largely based on the working hours consumed and their current rate.

Table 11.7 Added values created by the activities of the delivery process of Company B.

A	B	C	D	E	F
ACTIVITY	**Added value of physical work**	**Added value of services**	**Added value of information work**	**Total added value**	**Share of total added value of process**
Application planning		53 571		**53 571**	18,6 %
Purchasing	3 600			**3 600**	1,3 %
Frame manufacturing	67 500			**67 500**	23,5 %
Covering	58 500			**58 500**	20,3 %
Connecting products	5 400			**5 400**	1,9 %
Final assembling	90 000			**90 000**	31,3 %
Testing	9 000			**9 000**	3,1 %
TOTAL / PROCESS	**234 000**	**53 571**		**287 571**	

Table 11.8 shows the corresponding activity costs. These include direct work cost, the cost of monthly-paid personnel and the cost caused by tied-up current assets.

Table 11.8 Activity cost of the delivery process of Company B.

A	G	H
ACTIVITY	**Actual activity costs**	**Share of process cost**
Application planning	**45 492**	16,6 %
Purchasing	**6 010**	2,2 %
Frame manufacturing	**63 364**	23,2 %
Covering	**58 198**	21,3 %
Connecting products	**5 800**	2,1 %
Final assembling	**83 629**	30,6 %
Testing	**11 011**	4,0 %
TOTAL PROCESS COST	**273 505**	

On the basis of the identification of the added value created and the cost, the efficiencies realised in the activities were determined (Table 11.9).

Table 11.9 Activity efficiencies of the delivery process of Company B.

A **ACTIVITY**	E **Total added value**	G **Actual activity costs**	I = E / G **Actual activity efficiency**
Application planning	53 571	45 492	**1,18**
Purchasing	3 600	6 010	**0,60**
Frame manufacturing	67 500	63 364	**1,07**
Covering	58 500	58 198	**1,01**
Connecting products	5 400	5 800	**0,93**
Final assembling	90 000	83 629	**1,08**
Testing	9 000	11 011	**0,82**
TOTAL	**287 571**	**273 505**	**1,05**

In determining the targeted optimal efficiencies for each activity (Table 11.10), the core competence included in the activities *Application planning*, *Frame manufacturing* and *Covering* was stressed. As regards Covering, consideration of a construction modification had also led to a discussion of a reform of the mode of operation. At this stage, however, the study was limited to the present construction and the improvement potential found in its realisation process.

Table 11.10 Targeted optimal efficiency of the activities in the delivery process of Company B.

A **ACTIVITY**	E **Total added value**	G **Actual activity costs**	I = E / G **Actual activity efficiency**	J **Targeted optimal efficiency**
Application planning	53 571	45 492	1,18	**2,00**
Purchasing	3 600	6 010	0,60	**1,33**
Frame manufacturing	67 500	63 364	1,07	**2,00**
Covering	58 500	58 198	1,01	**2,00**
Connecting products	5 400	5 800	0,93	**1,33**
Final assembling	90 000	83 629	1,08	**1,50**
Testing	9 000	11 011	0,82	**1,33**
TOTAL	**287 571**	**273 505**	**1,05**	**1,76**

11.2.5 Level of development

The efficiency achievable through optimisation was clearly higher than the experimental goal. It was therefore decided to continue the optimisation.

11.2.6 Selection of activities for optimisation

The following step was to identify the activities for primary development, on the basis of the absolute saving potential included in each activity (Table 11.11).

Table 11.11 Saving potentials of activity costs in the delivery process of Company B.

A ACTIVITY	E Total added value	G Actual activity costs	I = E / G Actual activity efficiency	J Targeted optimal efficiency	K = E / J Targeted costs	L = G - K Absolute potential saving	M = L / G Comparative potential saving
Application planning	53 571	45 492	1,18	2,00	26 786	**18 706**	**41 %**
Purchasing	3 600	6 010	0,60	1,33	2 700	**3 310**	**55 %**
Frame manufacturing	67 500	63 364	1,07	2,00	33 750	**29 614**	**47 %**
Covering	58 500	58 198	1,01	2,00	29 250	**28 948**	**50 %**
Connecting products	5 400	5 800	0,93	1,33	4 050	**1 750**	**30 %**
Final assembling	90 000	83 629	1,08	1,50	60 000	**23 629**	**28 %**
Testing	9 000	11 011	0,82	1,33	6 750	**4 261**	**39 %**
TOTAL	**287 571**	**273 505**	**1,05**	**1,76**	**163 286**	**110 220**	**38 %**

On the basis of Table 11.11, the activities selected for primary development actions were *Frame manufacturing* and *Covering*.

11.2.7 First results of case study 2

The following primary development actions were identified in the delivery process of Company B:

The improvement potential of the activity *Frame manufacturing* was essentially based on a modification of construction by which the product frame was modified to utilise a modular structure.

As regards the activity *Covering*, method efficiency was improved by changing the method. Certain protective plates were attached by gluing instead of welding. After this, method efficiency was improved by employing welding fixtures in the welding still required to attach protective plates.

11.3 CASE STUDY 2, alternative view

Company B also wanted to study an alternative method of identifying development objects. Thus, analyses linked to increasing the speed of operation were also conducted on the process studied

11.3.1 Objectives

On the basis of similar processes managed completely by and within Company B, it was thought that the lead time of the process studied contained a significant shortening potential. Consequently the objective selected was to halve the actual lead time.

11.3.2 Performance measurements

The lead times per activity and the process lead time for the delivery process shared by Company B and its partner are presented in Figure 11.2.

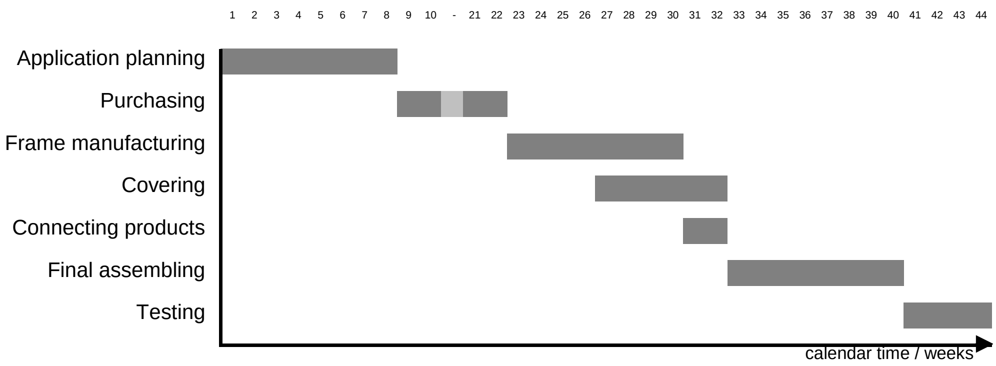


Figure 11.2 Lead times per activity and process lead time for the delivery process shared by Company B and its partner.

Table 11.12 shows the throughput times according to Figure 11.2 inside the critical path of the process.

Table 11.12 Throughput times on the critical path of the process in Company B.

A	B	C
ACTIVITY	**Throughput time inside critical path / days**	**Share of total throughput time**
Application planning	**56**	18,2 %
Purchasing	**98**	31,8 %
Frame manufacturing	**28**	9,1 %
Covering	**28**	9,1 %
Connecting products	**14**	4,5 %
Final assembling	**56**	18,2 %
Testing	**28**	9,1 %
TOTAL	**308**	

Table 11.13 presents the work times per activity corresponding to the throughput time.

Table 11.13 Value adding work times per activity on the critical path of the process in Company B.

A	D	E
ACTIVITY	**Actual value adding work time / hours**	**Share of total value addinng work time of process**
Application planning	**1 091**	21,4 %
Purchasing	**80**	1,6 %
Frame manufacturing	**750**	14,7 %
Covering	**867**	17,0 %
Connecting products	**120**	2,3 %
Final assembling	**2 000**	39,2 %
Testing	**200**	3,9 %
TOTAL	**5 108**	

Table 11.14 presents the actual efficiency of time consumption per activity, determined on the basis of Tables 11.12 and 11.13.

Table 11.14 Actual efficiency of time consumption per activity in the delivery process of Company B.

A	B	D	F = D / (B x 24)
ACTIVITY	**Throughput time inside critical path / days**	**Actual value adding work time / hours**	**Actual efficiency of time consumption**
Application planning	56	1 091	**81,2 %**
Purchasing	98	80	**3,4 %**
Frame manufacturing	28	750	**111,6 %**
Covering	28	867	**129,0 %**
Connecting products	14	120	**35,7 %**
Final assembling	56	2 000	**148,8 %**
Testing	28	200	**29,8 %**
TOTAL	**308**	**5 108**	**69,1 %**

Table 11.15 shows the optimal value adding work time and the corresponding theoretical efficiency of time consumption per activity in the delivery process of Company B. A significant reduction in the value adding work time in the activity *Final assembling* is based on the immediate reduction of value adding work time enabled by the adoption of a modular product architecture and by carrying out activities simultaneously.

Table 11.15 Optimal value adding work time and the corresponding theoretical efficiency of time consumption per activity in the delivery process of Company B.

A ACTIVITY	B Throughput time inside critical path / days	D Actual value adding work time / hours	E Optimal value adding work time / hours	F = D / (B x 24) Actual efficiency of time consumption	G = E / (B x 24) Theoretical efficiency of time consumption
Application planning	56	1 091	**1091**	81,2 %	**81,2 %**
Purchasing	98	80	**80**	3,4 %	**3,4 %**
Frame manufacturing	28	750	**750**	111,6 %	**111,6 %**
Covering	28	867	**767**	129,0 %	**114,1 %**
Connecting products	14	120	**120**	35,7 %	**35,7 %**
Final assembling	56	2 000	**1231**	148,8 %	**91,6 %**
Testing	28	200	**10**	29,8 %	**1,5 %**
TOTAL	**308**	**5 108**	**4 049**	**69,1 %**	**54,8 %**

Table 11.16 presents the targeted optimal efficiency of time consumption in the delivery process shared by the companies. These are largely based on the best practices achieved in Company B. Table 11.16 also shows the targeted optimal throughput times per activity, determined on the basis of the targeted efficiency of time consumption as defined.

Table 11.16 Targeted optimal throughput times per activity in Company B.

A ACTIVITY	B Throughput time inside critical path / days	E Optimal value adding work time / hours	F = D / (B x 24) Actual efficiency of time consumption	G Theoretical efficiency of time consumption	H Targeted optimal efficiency of time consumption	I = E / 24 / H Targeted optimal throughput time
Application planning	56	1 091	81,2 %	81,2 %	**300,0 %** →	**15,2**
Purchasing	98	80	3,4 %	3,4 %	**4,3 %** →	**77,5**
Frame manufacturing	28	750	111,6 %	111,6 %	**200,0 %** →	**15,6**
Covering	28	767	129,0 %	114,1 %	**200,0 %** →	**16,0**
Connecting products	14	120	35,7 %	35,7 %	**200,0 %** →	**2,5**
Final assembling	56	1 231	148,8 %	91,6 %	**250,0 %** →	**20,5**
Testing	28	10	29,8 %	1,5 %	**6,0 %** →	**6,9**
					→	
TOTAL	**308**	**4 049**	**69,1 %**	**54,8 %**	**109,4 %**	**154,2**

11.3.3 Level of development

Table 11.16 leads to the conclusion that the goal set, i.e., halving the lead time, could be achieved by optimising the lead time of the process.

11.3.4 Selection of activities for optimisation

Company B identified the activities primarily selected for increasing the speed of operation on the basis of Table 11.17.

Table 11.17 Absolute and relative potentials to decrease throughput times in Company B.

A ACTIVITY	B Throughput time inside critical path / days	E Optimal value adding work time / hours	H Targeted optimal efficiency of time consumption	I = E / 24 / H Targeted optimal throughput time	J = B - I Potential to decrease throughput time	K = J / B Wasted share of throughput time
Application planning	56,0	1 091	300,0 % →	15,2	**40,8**	**73 %**
Purchasing	98,0	80	4,3 % →	77,5	**20,5**	**21 %**
Frame manufacturing	28,0	750	200,0 % →	15,6	**12,4**	**44 %**
Covering	28,0	767	200,0 % →	16,0	**12,0**	**43 %**
Connecting products	14,0	120	200,0 % →	2,5	**11,5**	**82 %**
Final assembling	56,0	1 231	250,0 % →	20,5	**35,5**	**63 %**
Testing	28,0	10	6,0 % →	6,9	**21,1**	**75 %**
			→			
TOTAL	**308,0**	**4 049**	**109,4 %**	**154,2**	**153,8**	**50 %**

On the basis of Table 11.17, the greatest potential for reducing lead times is contained by the activity *Application planning*.

11.3.5 Alternative results of case study 2

The greatest development potential in the activity *Application planning* was linked to the decrease of value adding lead time. The throughput of the key resources of the activity could be improved by improving the work productivity of the resources. The improvement of work productivity was based on a change of method: a product configurator was introduced in the activity to determine customer-specific variations. The use of the configurator requires a clearly modular product architecture and clear interfaces between the modules, matters on which Company B itself has an extensive experience. The configurer also improved the conditions of work in other activities by making product information more streamlined.

11.3.6 Discussion of case study 2

Following are some comments by the company management on the analysis process and its final results:

”A disciplined way of estimating potential, a useful tool.”

”The value-based approach may become a tool; it may be used in team work to identify shared goals.”

”You have to have a lot of experience in order to determine the optimalities to strive for. You also have to be able to define longer-term goals, 'to see which way you are taking your crowd'. If you have 'simply decided' the optimalities to go for and the goals are not reflected in them, you may end up in a blind alley.”

”In virtual organisations, where the operational management may sit away from the locality where the operation is carried out, the tool may be an excellent way of setting up a good marching order, provided the analyses are carried out with care (= by the right people). Numbers are very powerful, especially if they are more or less the only tangible thing to present. On the other hand, in the SME sector the analysis can be 'an eye-opener', because people tend to think they know things.”

”Tools like this easily remain one-timers. How can you link regular analysis sufficiently strongly with continuous development? Of course, it depends largely on the management whether it is carried out continuously or not. At this point you should think about how to help the management in making this a continuum. One possibility would be to integrate development philosophy and decision diagrams with current quality policy / process descriptions. The rest will remain, and should remain, the concern of the management.”

11.4 CASE STUDY 3

Company C designs, manufactures and markets products which it has developed for the global market; the share of exports is about 90%.

11.4.1 Objectives

The company has invested strongly in improving and speeding up the order–delivery process. In this context, the target is to study the management of resource costs.

Due to a lack of comparison data and the lack of experience on the approach, it was not possible to set a target value for the optimality of resource cost management.

11.4.2 Selection of resources for primary consideration

Resources and resource costs

Since, in addition to selling machines and equipment, Company C also rents its products, equipment for rent was treated as a separate resource. Company C has subsidiaries of its own. As the turnover of sales receivables from the subsidiaries is essentially different from those from other resellers, sales receivables from subsidiaries were treated as a separate resource inside the financial assets. The resources and the corresponding resource costs of Company C are presented in Table 11.18.

Table 11.18 Resources and corresponding resource costs of Company C.

A	B	C
RESOURCE	**Actual resource cost**	**Share of total costs**
personnel, monthly paid	**1 211**	29,1 %
personnel, hourly paid	**2 060**	49,5 %
energy	**170**	4,1 %
current assets/materials	**56**	1,3 %
current assets/WIP	**19**	0,5 %
current ass./finished prod.	**12**	0,3 %
fixed assets/machines	**63**	1,5 %
fixed assets/ADP	**4**	0,1 %
fixed assets/rent mach.	**136**	3,3 %
fixed assets/buildings	**207**	5,0 %
liquid assets/receivables	**106**	2,6 %
liquid assets/receiv./subs.	**84**	2,0 %
liquid assets/cash	**8**	0,2 %
OTHERS	**24**	0,6 %
TOTAL	**4 159**	

Optimality of resource economy

In determining the unit costs of each resource (Table 11.19), the annual interest on foreign capital and the annual depreciation estimated for each property item was taken into consideration when determining the cost of different property items.

Table 11.19 Optimality of resource economy in Company C.

A	B	D	E	F	G	H
					= F / E	=(1-G) x B
RESOURCE	**Actual resource cost**	**Unit of resource cost**	**Actual unit cost of resource**	**Optimal resource unit cost**	**Optimality of resource economy**	**Saving potential based on economy**
personnel, monthly paid	1 211	€/month	**3 456**	**3 200**	**93 %**	**90**
personnel, hourly paid	2 060	€/hour	**11,49**	**11,49**	**100 %**	
energy	170	€/MWh	**33**	**30**	**91 %**	**15**
current assets/materials	56	%	**4,0 %**	**4,0 %**	**100 %**	
current assets/WIP	19	%	**4,0 %**	**4,0 %**	**100 %**	
current ass./finished prod.	12	%	**4,0 %**	**4,0 %**	**100 %**	
fixed assets/machines	63	%	**14,0 %**	**14,0 %**	**100 %**	
fixed assets/ADP	4	%	**37,3 %**	**37,3 %**	**100 %**	
fixed assets/rent mach.	136	%	**37,3 %**	**37,3 %**	**100 %**	
fixed assets/buildings	207	%	**9,0 %**	**9,0 %**	**100 %**	
liquid assets/receivables	106	%	**4,0 %**	**4,0 %**	**100 %**	
liquid assets/receiv./subs.	84	%	**4,0 %**	**4,0 %**	**100 %**	
liquid assets/cash	8	%	**4,0 %**	**4,0 %**	**100 %**	
OTHERS	24				**100 %**	
TOTAL	**4 159**				**97 %**	**105**

Because of the relatively good financial situation of the company it was found that the interest cost on foreign capital was already optimal. In terms of economy, then, the main interest was focused on the payroll cost of monthly-paid personnel and on energy.

Optimalities of resource amounts

The company management felt that employees used their working hours primarily for working, which could be seen in the actual and optimal utilisation of resources as presented in Table 11.20. Although the company's resource *Degree of utilisation* is 40–60 hrs/wk, the actual (and optimal) utilisation rate was set to correspond to a degree of utilisation of 164 hrs/wk.

Table 11.20 Optimalities of resource amounts in Company C.

A	B	I	I+	J	K	L	M
RESOURCE	Actual resource cost	Measure of utilisation		Realised resource utilisation	Optimal resource utilisation	= J / K (att. I+) Optimality of resource utilisation	= (1-L) x B Saving potential based on utilisation
personnel, monthly paid	1 211	use of working time		**0,75**	**0,75**	**100,0 %**	
personnel, hourly paid	2 060	use of working time		**0,75**	**0,75**	**100,0 %**	
energy	170	useful energy		**0,80**	**0,90**	**88,9 %**	**19**
current assets/materials	56	turnover		**8,57**	**8,57**	**100,0 %**	
current assets/WIP	19	turnover		**29,75**	**29,75**	**100,0 %**	
current ass./finished prod.	12	turnover		**63,79**	**63,79**	**100,0 %**	
fixed assets/machines	63	utilisation rate		**20,83 %**	**46,67 %**	**44,6 %**	**35**
fixed assets/ADP	4	utilisation rate		**13,33 %**	**13,33 %**	**100,0 %**	
fixed assets/rent mach.	136	utilisation rate		**30,00 %**	**50,00 %**	**60,0 %**	**55**
fixed assets/buildings	207	utilisation rate		**37,50 %**	**60,00 %**	**62,5 %**	**77**
liquid assets/receivables	106	receivables %	1	**15,27 %**	**15,00 %**	**98,3 %**	**2**
liquid assets/receiv./subs.	84	receivables %	1	**123,53 %**	**15,00 %**	**12,1 %**	**74**
liquid assets/cash	8	cash %	1	**1,03 %**	**1,03 %**	**100,0 %**	
OTHERS	24			**3,07 %**	**3,07 %**	**100,0 %**	
TOTAL	**4 159**					**94 %**	**261**

In terms of utilisation, the use of buildings and the large share of sales receivables from subsidiaries played the most significant roles.

Resources selected for primary consideration

Table 11.21 shows the combined effects of resource economy and resource utilisation. According to the table, the optimal resource cost is 91% of the company's actual cost, and the associated annual saving potential is € 365 000. Judging by Table 11.21, primary attention should be focused on monthly-paid personnel, buildings and sales receivables from subsidiaries.

Table 11.21 Identification of the resources to be developed in Company C.

A	B	G	L	N	O	P
RESOURCE	Actual resource cost	Optimality of resource economy	Optimality of resource utilisation	= B x G x L Optimal resource cost	= G x L Optimality of resource cost	= B - N Saving potential of resource cost
personnel, monthly paid	1 211	93 %	100 %	**1 121**	**93 %**	**90**
personnel, hourly paid	2 060	100 %	100 %	**2 060**	**100 %**	
energy	170	91 %	89 %	**137**	**81 %**	**33**
current assets/materials	56	100 %	100 %	**56**	**100 %**	
current assets/WIP	19	100 %	100 %	**19**	**100 %**	
current ass./finished prod.	12	100 %	100 %	**12**	**100 %**	
fixed assets/machines	63	100 %	45 %	**28**	**45 %**	**35**
fixed assets/ADP	4	100 %	100 %	**4**	**100 %**	
fixed assets/rent mach.	136	100 %	60 %	**82**	**60 %**	**55**
fixed assets/buildings	207	100 %	63 %	**129**	**63 %**	**77**
liquid assets/receivables	106	100 %	98 %	**105**	**98 %**	**2**
liquid assets/receiv./subs.	84	100 %	12 %	**10**	**12 %**	**74**
liquid assets/cash	8	100 %	100 %	**8**	**100 %**	
OTHERS	24	100 %	100 %	**24**	**100 %**	
TOTAL	**4 136**	**97 %**	**94 %**	**3 771**	**91 %**	**365**

11.4.3 Results of case study 3

On the basis of the analyses carried out, the following savings potentials in resource costs and their causing factors were identified.

Monthly-paid personnel represented the resource sort enabling the greatest savings potential (€90 000/a). This was due to the fact that the income level was higher than average. However, the company regards personnel as a resource of primary importance, and it wants to continue enjoying the exceptionally small turnover of personnel.

The second-largest savings potential (€77 000/a) could be noted in the use of the facilities. The poor utilisation of the facilities was due to the fact that operation was mainly organised in one shift. Correspondingly, the fifth-largest savings potential (€35 000/a) could be derived from machinery and equipment, for the same reason.

The third-largest savings potential (€74 000/a) is associated with the large volume of receivables from a subsidiary. The receivables have mounted gradually over time. The current situation does not afford the possibility of rapid action.

The fourth-largest savings potential (€55 000/a) is based on the poor utilisation rates of machines rented to customers. The potential development action include the increase of sales (renting) using the same machines, by means of boosting sales, or the cutting down of the number of machines for rent.

11.4.4 Discussion of case study 3

Company C did not immediately undertake any development actions on the basis of the analyses conducted. Following are comments by the management on the process of analysis and its final results:

”The final result is credible, though partly self-evident. An interesting approach in that it is rapid and brings out pointers which should be looked at more carefully. These are not absolute truths, but they provoke thought and encourage to take note of things.”

”The level of detail varies at different points of the analysis. Absolute truths can be discovered, but fuzzy areas remain. What is the result of comparing two fuzzy things, will you even have pointers?”

”Experience plays an important role in determining optimalities. Comparison data on optimalities is needed. What is a realistic optimality, when should you be satisfied?”

”Could serve as a tool for a consultant.”

”The approach might be called resource brokering.”
”The approach could serve as a new angle for looking at the balance sheet. Focusing on costs which are the largest according to a traditional approach will not necessarily reveal the greatest savings potential.”

11.5 Evaluation of results

All companies applied the method developed and presented in this study, although to different extents. All analyses were not always carried out in the form presented in Chapters 7, 8, 9 and 10. At its best, in fact, the method works as an expert's tool kit, from which it is possible to select appropriate tools to meet the need at hand. In other words, the existing modules of the model are used to vary the structure to suit each case.

Optimisation of operational quality

The analyses carried out and the development actions identified with them were considered justifiable and logical by the companies. The determining of the values created by different activities was regarded as an unfamiliar approach. Companies felt that the traditional, cost-based approach was more familiar and safer. Correspondingly, the accuracy of determining targeted optimal efficiencies was not regarded as convincing by all, in the absence of comparison data.
The problematic nature of determining the added value attainable is emphasised when one takes into account the fundamental role of these key figures for the method developed in this study, in the context of assessing operational quality.

Optimisation of the management of resource costs

The volume of work involved in the analyses required to optimise the management of resource costs was unexpectedly low. Simply using the company's balance sheet and its key figures is surprisingly useful for determining the baseline data of a company. As was noted by the representatives of Company C, the determining of targeted economies and utilisation rates requires experience and comparison data on similar practices.

Optimisation of speed

When examining an extensive process, the method presented here is of obvious help in identifying the most essential development objects, by making it possible to compare the activities included in a process. Calendar time has an equal value regardless of the nature of action, and when speed is prioritised as an operational success factor, making use of calendar time should always be regarded with equal seriousness.

PART V:

DISCUSSIONS,

TOPICS FOR FURTHER RESEARCH

12 CONCLUSIONS AND IMPLICATIONS

12.1 Discussion of results

On the basis of the research problem and the hypothesis presented, the following goals were set for the dissertation study:

1 Description of the basic concepts of development.

2 Development of a method for identifying development actions for the overall optimisation of the order–delivery process, so that
   - the development goals are derived from higher-level strategic goals,
   - objective analyses are used to guide towards the same end result independent of the analyst,
   - concrete development actions are proposed and
   - a process-based approach is applied.

Following is a discussion of whether these goals and the sub-goals included in them were attained.

Concepts of development

Chapters 2, 3 and 4 of this research report provide a description of the basic concepts of development. The concepts are based on the multiplicity of the development object, on the level of activity (when the development object consists of an activity) and on the level of development. The basic concepts presented help to understand the multi-directional nature of development and to position the development actions needed and achieved as part of a larger whole. The concepts have been used in determining the scope of and focusing the method for identifying development objects which is presented in this study.

The higher level of the structure of levels of development presented here may be regarded as a summary of different models presented in literature (such as Department of Defence, 2001, and Imai, 1986). A more detailed division of improvement into corrective and preventive measures and the optimisation between these helps to gain a better understanding of the roles of such aspects as *continuous improvement* and *benchmarking*.

Target orientation of development

In the method developed in this study, the goals of developing operational business activity are derived from higher-level strategic goals, with the help of the selected operational success factor and the corresponding key figures presented.

In a process-based approach, examination should not be limited to an individual company, but must be extended to the section of the value net which is affected by the process in question. Business processes inside the value net may be shared by the companies forming the value net, and so the processes may transcend company boundaries. However, it should be borne in mind that in the environment most familiar to the author, the value net as an approach is still immature. The forming of a value net should be based on the best available operations needed to realise a product to meet customer needs, rather than on a programmatic intention to reorganise existing resource structures. An entire value net rarely has the kind of strategic goals which could consistently be used to derive the goals for developing operational activity. In practice, therefore, the work is based on the strategic goals of a single company.

Systematic of the identification of development objects

The analyses developed in this study are reviewed in Chapters 7.4, 7.5, 8.2, 8.3, 9.2, 9.5, 10.2, 10.3 and 10.4.

In assessing the development potentials of each activity and resource with the method presented, key figures are determined for the activities and resources studied to make them commensurable.

The results gained from testing the method in client companies show that the analyses presented in this report form a consistent method of analysing selected business processes on the basis of determined operational success factors.

The objectivity of the analyses developed may be called into question to the extent that, although the analyses are presented in a quantitative form, some of them are nevertheless more qualitative in nature. The objectivity of the analyses carried out is weakened by the difficulty of determining *value*. In environments familiar to the author, the concretisation of the components of offered value as numerical values is an unfamiliar approach. Matters are traditionally considered from a cost point of view. In terms of the profit margin approach, all product components and all operations are often regarded as being of equal value with regard to the profit margin.

The approach adopted in this study may be said to contain similarities to Activity-Based Costing: the goal is not to gain absolutely correct information, but information which supports decision-making essentially better than current information.

Concreteness of the development actions proposed

The method developed in this study provides concrete indicative proposals for development actions.

The empirical study shows that the target companies were able to use the method to identify concrete development actions.

The issue whether the development actions proposed were the one and only correct ones was not analysed in the context of this study.

Process-basedness

The starting-point of the method developed is a business process and the development of the process performance, by identifying the greatest development potential in lower-level operations.

Summary

Empirical studies have demonstrated that the developed method is feasible.

Table 12.1 presents a summary of assessments of the characteristics of the development methods reviewed earlier and together with ABO.

Table 12.1 Summary of the characteristics of the development methods reviewed and ABO.

	goal-orientation of development	systematic identification	concreteness of proposals	process-basedness
ABO	good support	good support	good support	good support
ABM	poor support	partial support	poor support	good support
BPR	partial support	poor support	partial support	good support
BUNT	partial support	good support	partial support	good support
EFQM®	partial support	partial support	poor support	good support
JOT	poor support	partial support	good support	partial support
MSDD	good support	good support	good support	poor support
Six Sigma	poor support	good support	good support	partial support
SCOR	good support	partial support	partial support	good support
TOC	good support	partial support	partial support	partial support
Tuotto^{+}	partial support	partial support	partial support	partial support
VSM	partial support	partial support	good support	good support

■ = good support

▒ = partial support

□ = poor support

12.2 Scientific contribution of the dissertation

The evaluation presented in Chapter 5 showed that none of the examined methods for identifying development objects fully supported the requirements placed on such methods in this study. Section 12.1 allows the following conclusion concerning the primary contribution of this study: the method developed here for the identification of development objects succeeds in meeting the requirements set for such methods in this study.

It may also be noted that the key figures used in the analyses provide support to strategic decision-making in themselves. The key figures presented enable the concretisation of the operational core competence of the value net, and also the comparing of the corresponding performance capability between the value net studied and other corresponding operations. The knowledge thus derived may be used to support such strategic decisions as whether to outsource an operation or "make or buy" (MOB) decisions. A decision to outsource may also be regarded as a reform of the operation and/or resource structure, which will have to be taken if improvement does not result in a sufficient increase of performance capability.

As part of his duties, the author repeatedly takes part in discussions whose essential content could be expressed as the phrase "we need to do something". In general, it may be said that the discussion partners recognise the need for development and could often list a number of useful development actions. Using the method presented in this study to structure the ideas for development expressed in discussions has clearly helped to form a more consistent approach and order of work.

As was pointed out by representatives of Company C, the analyses employed for the management of resource costs can be used when analysing the company's balance sheet. The use of these analyses enables all resources to be compared in terms of their unrecognised saving potential.

12.3 Limitations of the study and indications for further research

The concept of product should be defined in a more precise manner. To take an example, the positioning of computer software in the product sort categories presented cannot always be regarded as unambiguous. In terms of the tangible media used, software may be regarded as a physical product, in terms of the control information which it contains it may be understood as an information product, or the software developer may be regarded as providing service thanks to the software.

Different interest groups must be allowed to have different visions of the product and the product architecture. It should be possible to view a single product from different 'windows' according to the viewer's needs. In fact, a similar concept has already been approached in various product data management systems. Likewise, it should be possible to identify the appropriate viewing parameters for considering the product and product architectures.

In this study, the maturity level of the product has only been considered indicatively for service products. It is conceivable that general methods of analysing product maturity could be found or developed, utilising similar analyses as those used for process maturity.

As with product maturity, a more detailed study of defining the product adaptability would be possible.

As was stated above, the value net as presented in this study is so far a distant concept for the Finnish metal workshop industry. There is an extensive scope for studying and understanding the concept of value net and the earning logic involved in it.

The analyses for studying operational quality are based on determining the added values created by different operations. The identification of values created in different operations is also extremely important from the viewpoint of understanding the earning logic of the company / value net. Despite the crucial importance of this issue, the only unambiguous method known to the author is to determine the standard time of physical work. More research and input is needed to understand and control the components which combine to form the value of the basic product.

The method presented here facilitates the definition of targeted optimal performances. As the method user gains more experience and the available "data bank" expands, supporting the company being developed in defining the appropriate target levels becomes easier.

The potential afforded by IT could have been stressed more in the concrete development proposals presented. The focus adopted in this study lay more in the streamlining and unifying of structures than in the automation of operations.

In the context of estimating the efficiency of time use, a more detailed study of the objectivity of determining the value adding working time would be possible. For physical work, objective working times, i.e., the standard times of work, may be defined by *time-and-motion study*, for instance. As regards service and information work, the definition of objective value adding work time also approaches the corresponding definition of added value created by the work. In terms of value determination, increasing the speed of operations thus faces the same problems as the development of operational quality.

12.4 Genericity of the method

There are no obstacles to applying the method here developed on other business processes or in different operational environments.

Nevertheless, the difficulty of determining the added value created by different operations should be borne in mind.

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Tampereen teknillinen yliopisto
PL 527
33101 Tampere

Tampere University of Technology
P.O. Box 527
FIN-33101 Tampere, Finland