Contents

1. ORGANIZATION SYSTEMS

1.1 Single-line Organization

A single line system may only receive orders/instructions from a central authority. A member of the organization has only a direct supervisor. Every job, every department is only connected to a single line with their superior authority (through official channels).

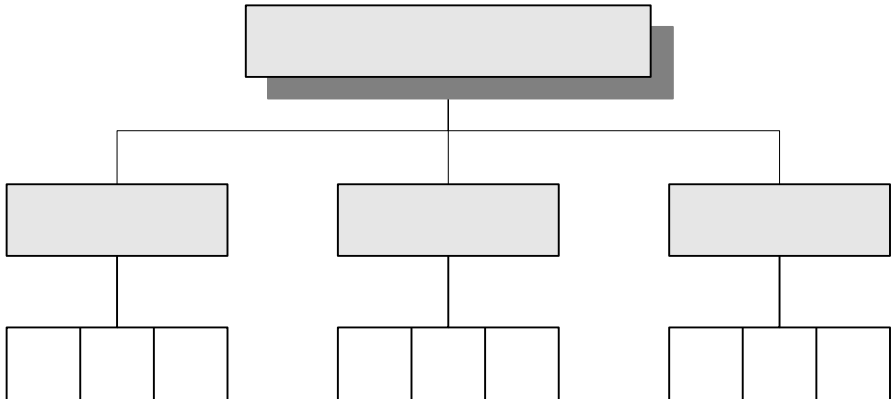


Figure 1.1: Single line organization structure form

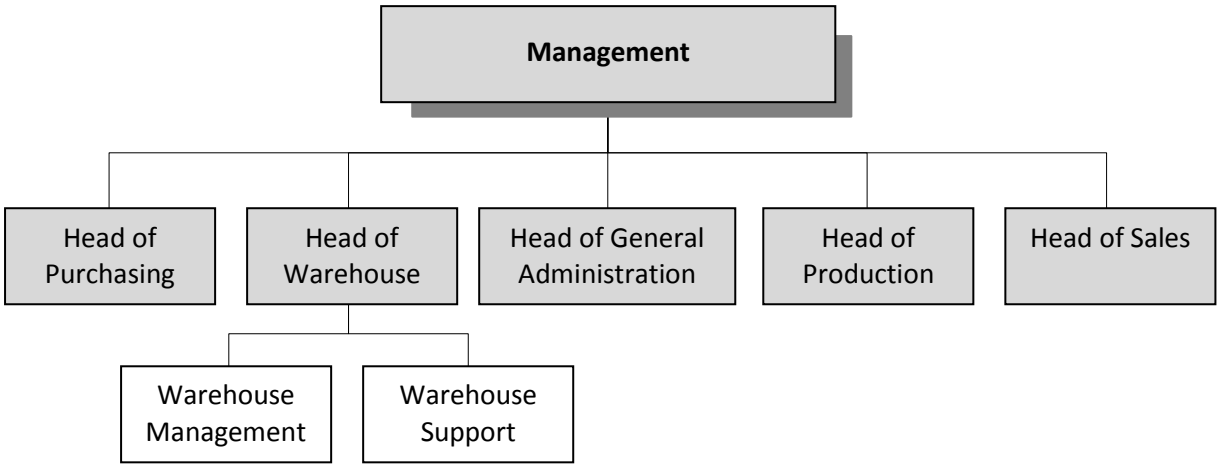


Figure 1.2: Single line system

First try to find some advantages and disadvantages without reading further.

Advantages	Disadvantages
■ Unique service routes ■ The superiors are always informed about everything ■ No competence disputes ■ Complete control possibility of decisions and instructions ■ Relatively simple organizational structure ■ Clear subordination relationships	■ Sometimes cumbersome official channels with adverse effects for important quick ■ Over stressing the supervisor for of ten trouble-free operations ■ The supervisor is the expert ■ Lengthy and cumbersome procedures ■ High levels of procedure with routine tasks and details

What can be concluded as a result of it?

The more a business is dependent on quick decisions and is market-oriented, the less suitable is the single-line-system. The decision to delay through the official channels is considered a crucial disadvantage.

1.2 Multiple-line Organization

The multi line organization is also called an/a operating/functional system. In this interpretation of the principle of functional specialization it is assumed that a particular site is not only dependent on one but on several direct superior authorities.

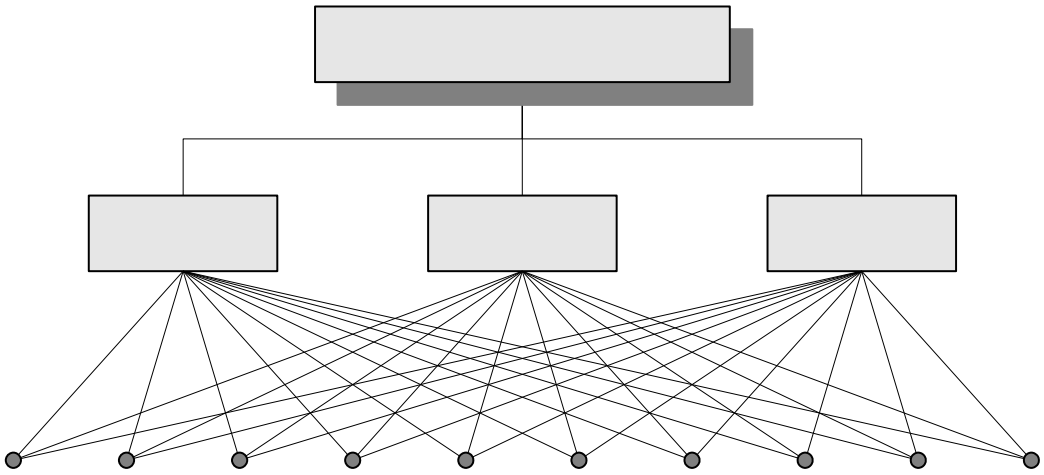


Figure 1.3: The multi line organizational structures

This system requires a specific delineation of each activities and competencies, as well as a consistent coordination of parent in punch. Conflict situations can be virtually unavoidable.

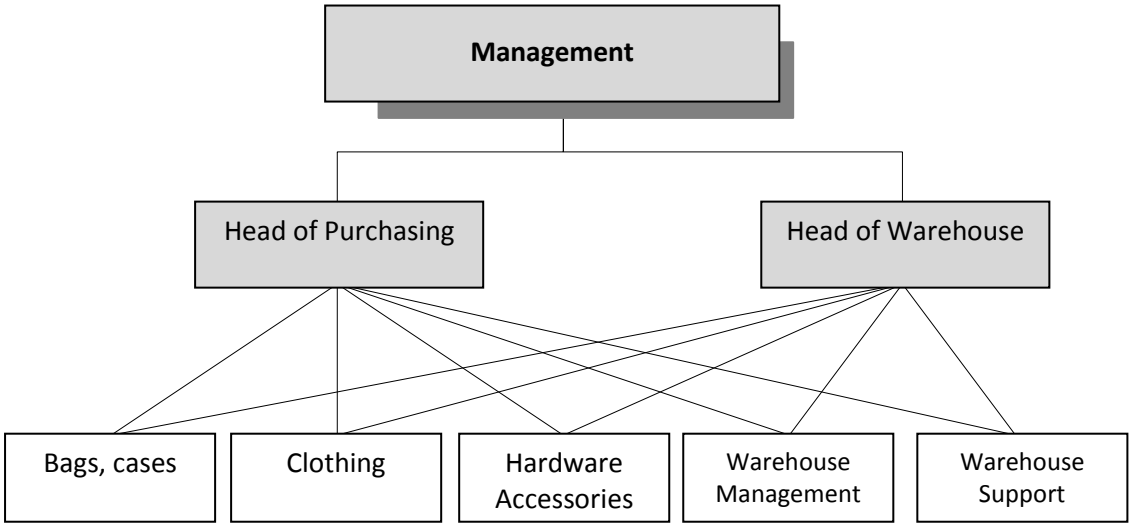


Figure 1.4: Multiple line organization

Advantages	Disadvantages
■ The cumbersome official channels of single-line systems is shortened. ■ Supervisors are expert in their area of competence and informed about all important aspects. They will not issue an instructioin if their area of expertise is actually affected. ■ The functional performance ability of the manager is enhanced. ■ Control by individual is avoided. ■ Professional and decision-making powers are matched.	■ Instructions by different supervisors may possibly lead. ■ Coordination problems of differences of opinion when instructions are given are possible. ■ There may be competence problems between managers. ■ There is no possibility of complete control when making decisions and giving instructions. ■ It is possible to play specialized supervisors against each other for subordinate positions. ■ Employees are unsure when incomplete or contradictory instructions are given. ■ The specialized supervisor has lost sight of the big picture. ■ No officials can be held clearly responsible for blunders. ■ The feeling of being directly subordinate to several managers can hinder employees performance.

1.3 Bar-line Organization

In this system, the advantages of the single-line system and multi-line system (function system) are used, but the disadvantages are restricted. The quality of decisions by line instances decreases with the increasing size of the company because no adequate decision-making and control is guaranteed. The executives are simply overworked and overburdened. New positions are formed which perform a support function.

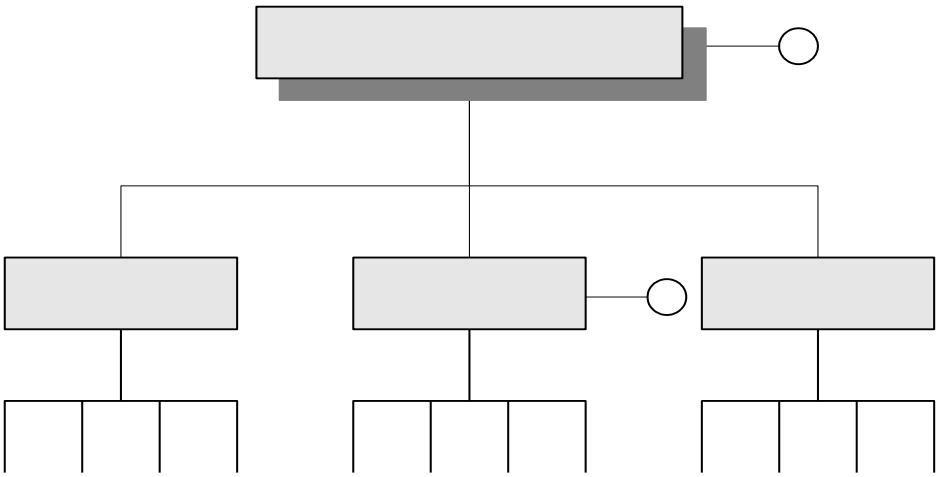


Figure 1.5: structure of the bar line organization

The administrative departments are staffed with specialists who have an independent function. They develop, plan and support the line management but may not give instructions.

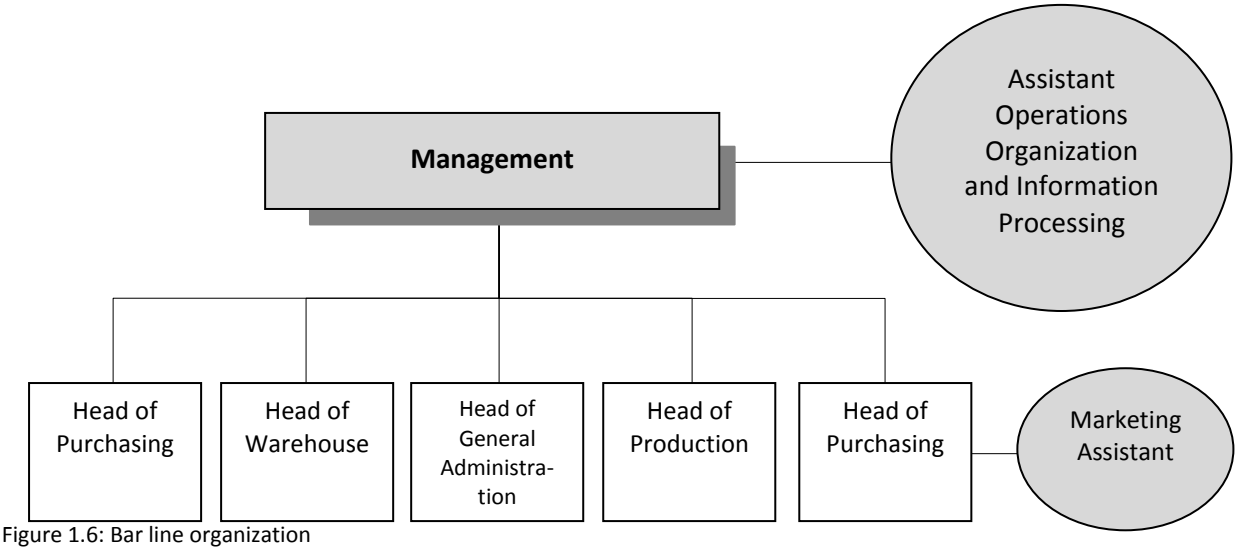


Figure 1.6: Bar line organization

Advantages	Disadvantages
■ The benefits of single and multi line system are retained. ■ Supervisors are advised and supported by specialists. ■ In-depth decisions are made. ■ Improve coordination of executives because of support. ■ Improve the quality of decision-making, as specialists in the administration are involved in the preparation of decisions.	■ Administrative departments tend to influence line management which may lead to conflicts of jurisdiction. ■ Line management can block projects of the administrative departments if the instructions from the Executive Board is not clear. ■ Lower authorities are often blinded by the special expertise of the administrative staff. ■ The cooperation of line management and administrative staff can be problematic.

Let us look at the co-operation between line management and administrative staff. Why are there problems here?

From the point of view of line management and often mentioned as a problem, is that major time and cost solutions which are thought to be ideal, do not meet the expectations. Theoretically exact solutions do not consider real life situations. The solution is not aligned with the overall business objectives. Co-ordination between administrative departments is insufficient when several people work on a project.

Of course the administrative departments also have something to say about line management for example, that there is no real willingness to cooperate in processing solutions. Solutions that affect or change the task of line management are not accepted. There is no full support in the implementation of drastic measures. Orders are seen as wrong in terms of their effect.

Our accountant thinks that it would be something to run away from! But it is not as bad as it seems because an administrative staff can also dominate, if trust in the subject-specific qualifications is high enough. You only need to convince your superiors of yourself.

You can do something for the productive cooperation of line management and the administrative departments. All you need to do is to set a few basic principles. Then you only need to be noticed. The administrative staff is not allowed to have any authority. Line management is obligated to give

information if the administrative departments request it. The line management has the right and above all the duty to take the help from the administrative departments especially considering that the specialists sit there. The administrative departments are obligated to inform the next higher authority if different line decisions are made against the advice of the administrative which in turn, could put the operation in danger. Information about important events of line management may only occur after consultation with the relevant line manager.

1.4 Divisionalisation / Business Organization

The development of new, rapidly expanding markets and the expansion of the product design (diversification) make the strategic and dispositive decisions in the company not only numerous, but also more diverse. The survival of traditional organizational structure with the long rigid official channels would lead to adjustment problems. The solution is made possible through a restructuring of the performing based to object-oriented organization. A company is no longer organized by functions, but by divisions and sectors. Under separate divisions the company can independently and on their own responsibility conduct their business.

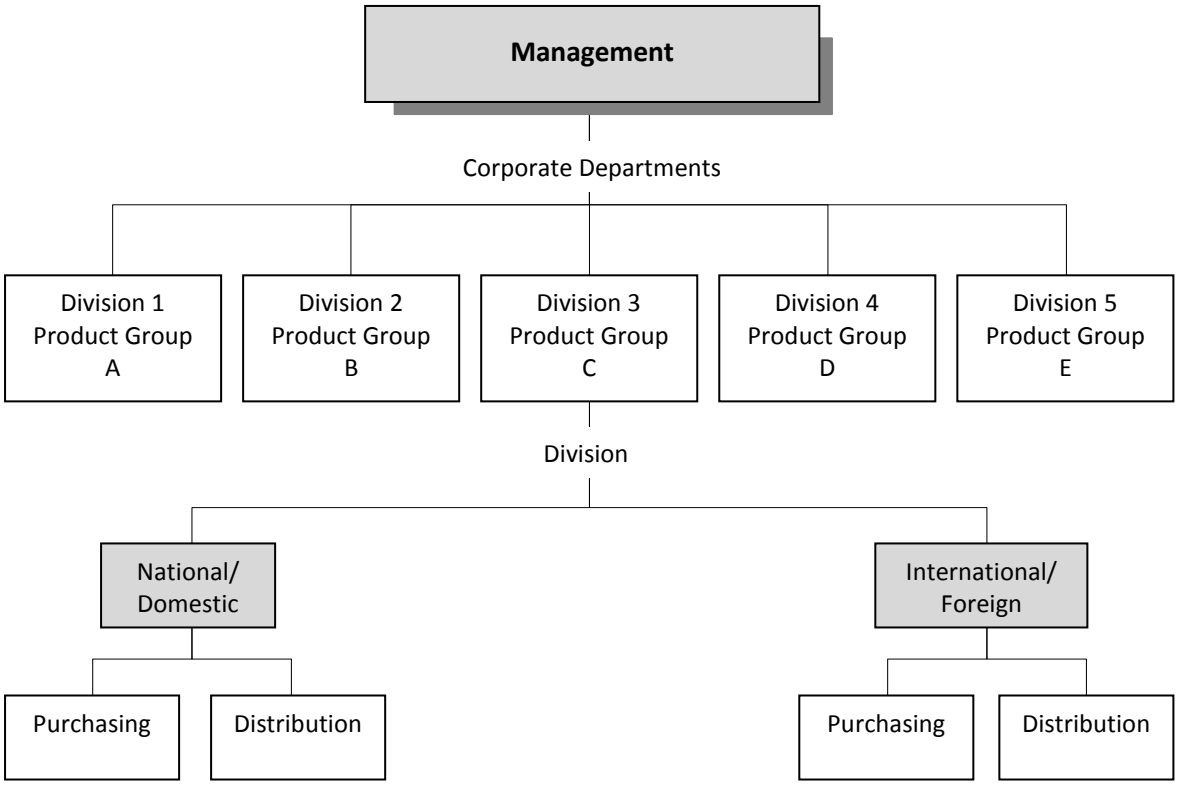


Figure 1.7: Division Organization

The corporate responsibility framework of the division manager generally occurs in two forms.

- **Profit Center:** The division manager is responsible for the increase in profits.
- **Cost center:** The division manager must achieve a specified sales amount within given costs.

Advantages	Disadvantages
■ Refined expertise through specialization ■ Short information routes ■ Quick reaction to changing market conditions	■ Danger lack of subordination of division manager regarding The company´s goals ■ Higher costs due to decentralization ■ Risk of business competition

1.5 Matrix Organization

In the matrix organization, the dominance of a structure criterion is lifted and two or more structural criteria are simultaneously and equally put together like a matrix. With the matrix organization one would like to achieve an increase in the flexibility of the organizational structure, and not just in the short term, but with longer duration. Criteria such as functions, products, regions, or projects can be selected.

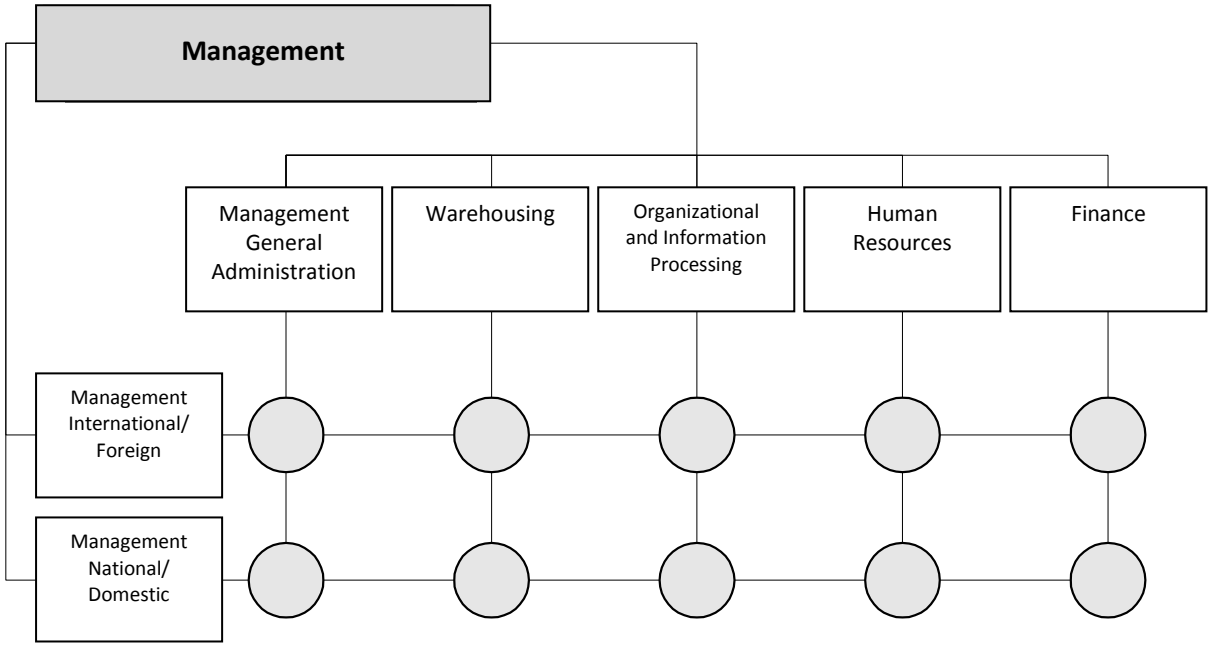


Figure 1.8: Matrix Organization

What arguments could be put forward for a matrix organization?

What arguments could be put forward for a matrix organization?
The result is a high problem-solving potential by combined use of different specialists. You are dealing with direct communication channels. There is great flexibility and adaptability to environmental changes through existing interconnections. The top managers are relieved. Teamwork is emphasized. The personal development of the employee is encouraged.

Advantages	Disadvantages
■ Easy decision making ■ Reduction the risk of division or department competition	■ Difficult situation for management in cases of a necessary dispute resolution between the different divisions or departments ■ Great need for communication ■ Risk of too many compromises and loss of time until the decision

As you can clearly see no system leads to an ideal company organization.

Let us summarize the various organizations:

- **Single line system:** Each employee has only one supervisor. Instructions and requirements can only be routed through strict official channels.
- **Operating system:** Different authorities can give instructions to a unit. An employee therefore, has several managers. Decisions can be implemented more quickly.
- **Bar- line system:** Line management are relieved by specialists, who advise and plan, but can give no instructions. The single line system or function can represent the basis.
- **Divisional/Business Organization:** A company is divided into separate divisions. Central departments are directly under management and take on tasks that are binding for the individual divisions.
- Matrix organization: Largely equal divisions or joint decisions. The management controls only in individual cases of discrepancies or special problems

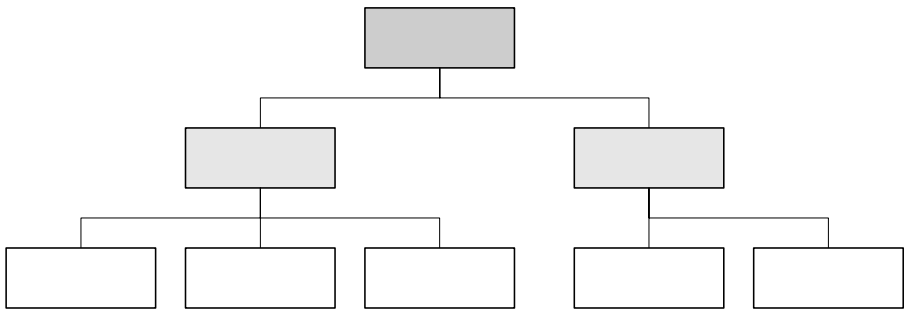
1.6 Organization chart

The following details must be considered in the creation of an organization plan, also called a organigram or organizational chart:

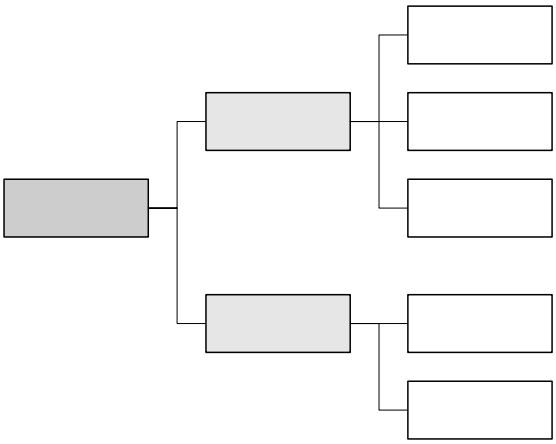
- How are the tasks of the positions/jobs distributed?
- How are the positions/jobs structured?
- Which positions are grouped into departments?
- What hierarchical order exists between the different authorities?
- Who shall be assigned to the management assistant position?
- What type of organizational structure should be chosen?

In the representation of an organization chart, there are often three forms:

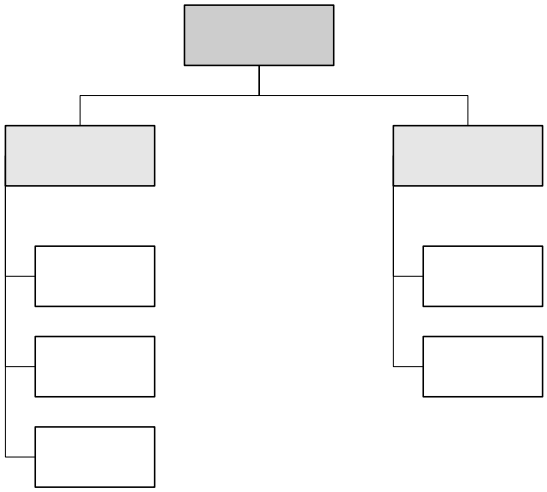
Vertical Display



Horizontal Display

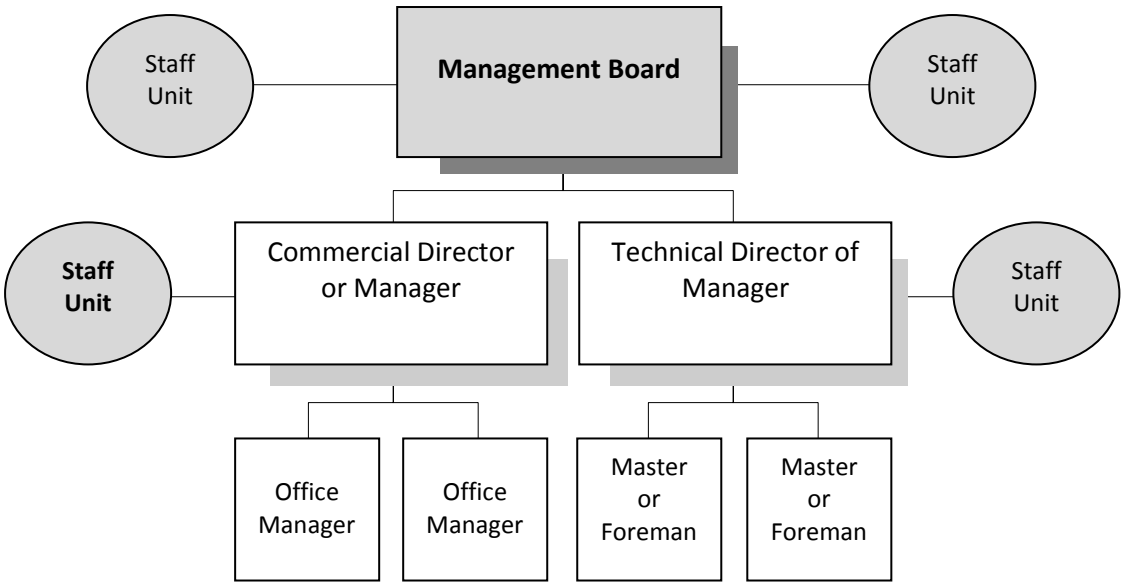


Hybrid (Vertical/Horizontal Combination)



A good organizational chart describes the different positions as desired by the personnel manager. A job description should include:

- Job title
- Job classification (superior, subordinate)
- Job tasks
- Job authority (such as signature powers)
- Job responsibility
- Job targets (they should, if possible be quantitatively specified)
- Deputies
- Job requirements (knowledge, skills, capability)



2. THE BASIS OF SCHEDULING

The fifth chapter deals with the forms of division of labor and planning. In addition, they also describe the factors influencing the design of material flow and you learn about the different types of work systems.

2.1 Forms of Organization of the Work Processes

Basically, the organization governs the interaction of people and machines in operation and in temporal and spatial terms. There are a few goals that you should keep in mind when designing the workflow process:

- The execution of work should be possible with the least effort (economic principle).
- The lead time of all processes can be optimized
- The capacity utilization is to be maximized.
- The number of processing errors is to be minimized
- The work must be performed on schedule, and it should also be more user-friendly.

And now ***you*** plan a reasonable process. As you may be aware by now (do you remember?), the workflow process is a sequence of related operations in time and space. Therefore, you need to first examine the following criteria:

- the division of the procedure in individual operations
- the chronological order of operations
- the spatial arrangement of workplaces
- the means of transport for the materials

2.2 Representation of Work Processes

A workflow is divided into individual tasks, subtasks, and work items. The sequence of the tasks must be defined and the work stations determined.

Table 2.1: Matching Questions

What should be done?	Work item
Where should this activity be done?	Working area
How should this activity be done?	Work equipment and working method
When should this activity be done?	Processing time

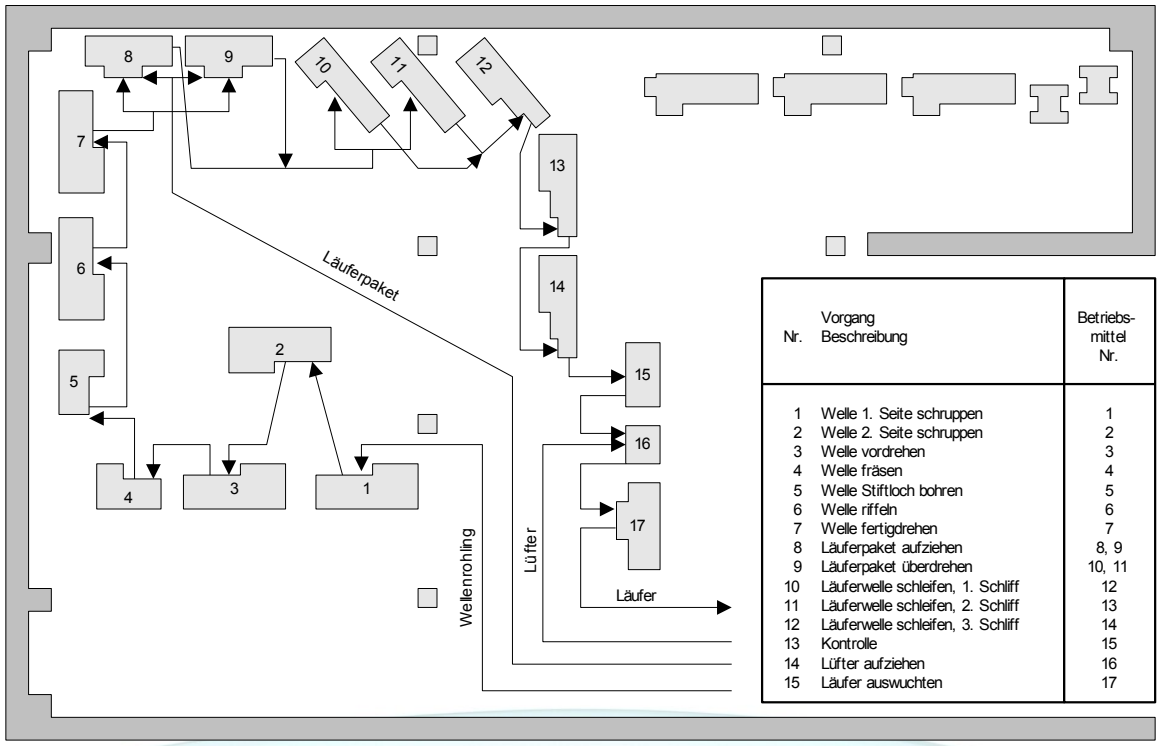
Two different types of workflows can be displayed:

- The verbal presentation and the
- Graphical representation.

In the ***verbal representation*** the process is described in words. Most are work instructions or job descriptions or organizational instructions.

The ***graphical representation*** explains the process in the figurative or symbolic form.

Right now you will perhaps remember some of these representations, such as a floor plan presentation which shows the workflow between jobs and departments. Do you know flow charts? They show the logical process, through symbols. Bar graphs and network diagrams are certainly familiar terms. Here the dates are included. Matrix representations are also a possibility. Through the rows and columns, it is possible to combine two aspects.



Nr.	Vorgang Beschreibung	Betriebs-mittel Nr.
1	Welle 1. Seite schruppen	1
2	Welle 2. Seite schruppen	2
3	Welle vordrehen	3
4	Welle fräsen	4
5	Welle Stiftloch bohren	5
6	Welle riffeln	6
7	Welle fertigdrehen	7
8	Läuferpaket aufziehen	8, 9
9	Läuferpaket überdrehen	10, 11
10	Läuferwelle schleifen, 1. Schliff	12
11	Läuferwelle schleifen, 2. Schliff	13
12	Läuferwelle schleifen, 3. Schliff	14
13	Kontrolle	15
14	Lüfter aufziehen	16
15	Läufer auswuchten	17

Figure 2.1: Floor Plan Representation

2.3 Work Planning

For each part, each module and the product itself, the technical production process (production process) is precisely held in a separate work plan.

The work plan includes the operations for a product, a module or an individual part. It also includes the workplace (cost center, machine), the necessary equipment, aids and tools, the wage groups, the set-up times and standard times for each unit, as well as the necessary details of the work piece and the feedstock.

Different bases are necessary for the creation of a work plan:

- Drawing the product which is graphically described as a representation
- Bill of material as a list of raw materials, parts and rank groups of the product
- Job descriptions, that includes the workplace and work tasks
- Machine information, the details of the machines to be used is documented
- Order quantities and deadlines that are necessary for the work planning

By the way, a separate chapter is dedicated to the task list.

What is the basis of work plan available to us and what will be the result?

How about the following small list?

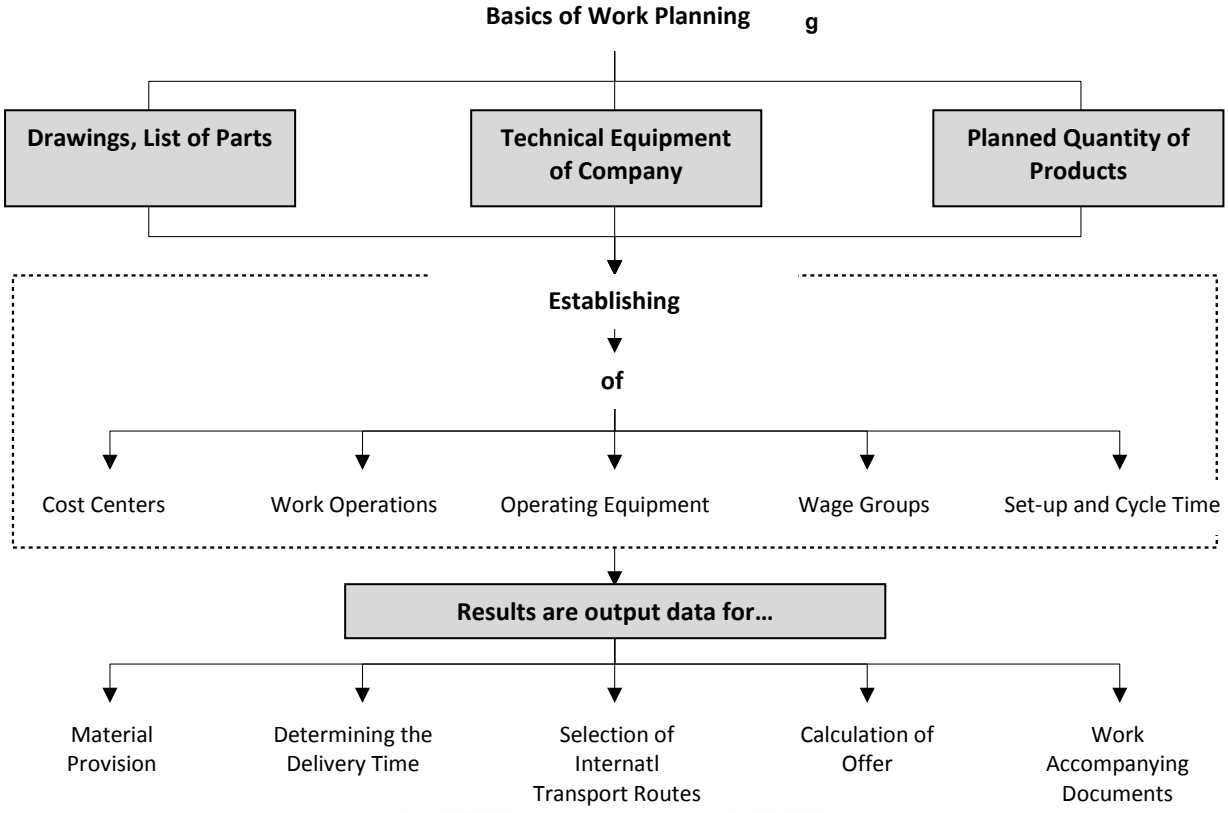


Figure 2.2: Basis of Work Planning

2.4 Stages of Work Flow Planning

The work flow planning is based on the work plans. They provide information on the questions of from whom, what, where, how, with what and in what time something is to be produced.

We have already heard that the workflow is a sequence of to related operations in space and time according to REFA. It should establish a meaningful interaction of individual positions, work steps, and working groups. The workflow should be designed as efficiently and human-friendly as possible. The need for a project workflow is divided into individual tasks. They each describe the necessary tasks within a workplace that leads to the fulfillment of the overall task. A small example to illustrate this point:

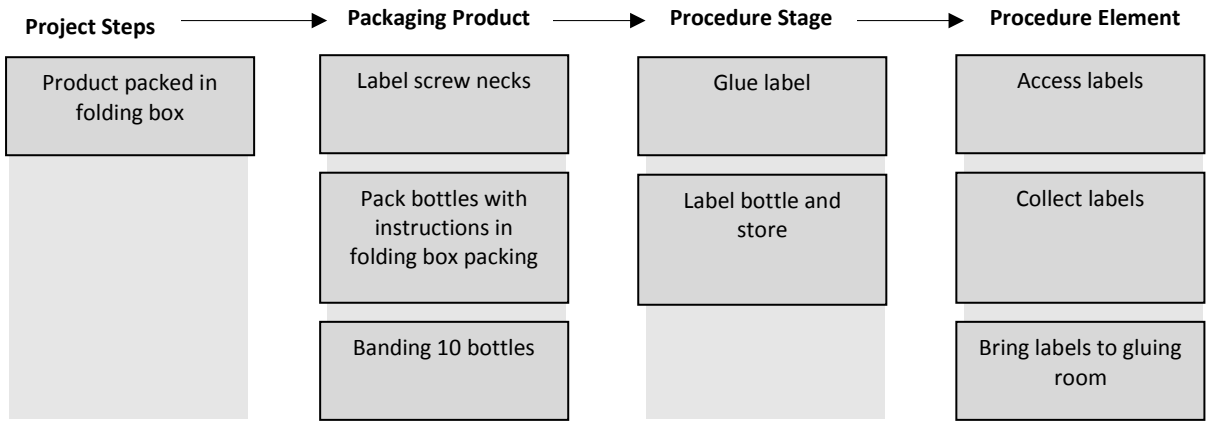


Figure 2.3: Outline the project level "product packed in folding boxes" in process steps

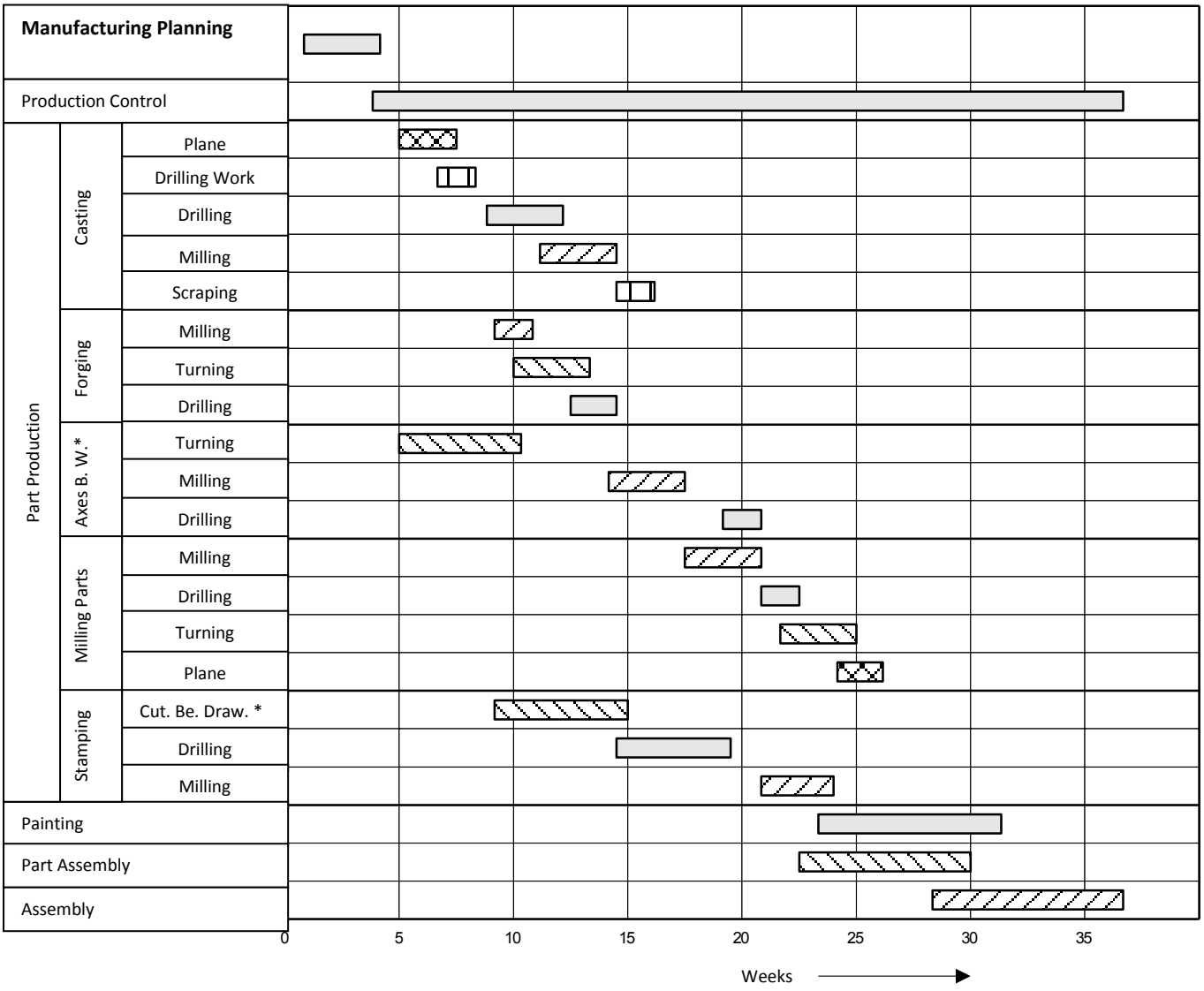
2.5 Determination of Processing Dates

The cycle time is the production time from the beginning until the end of production process. The actual processing times and the intervening technically conditional congestion and waiting times must be considered. The lead time is calculated as follows:

Table 2.2: Cycle Time

Type of Time	**captured**
Present Time	Execution time
+ Interim Time	1. Storage times 2. Waiting times 3. Transport times
+ Extra Time	Contingency for unexpected events (such as engine failure) (Safety margin for unplanned events – eg. Machine breakdown.)
= Cycle time	Intermediate and additional times are fixed on the basis of operational experience. (Additional time and extra time are determined on the basis of operational experience.)

The cycle results from the sum of all time schedules of a product. From the time schedules one can read, when, in what order and at what time the individual manufacturing operations must be performed. A short-term time schedule will serve to illustrate this.



*Cutting Bendable Drawing
*Axes Bolts Waves

Figure 2.4: Time plan / Deadline

3. APPLICATION OF METHODS FOR REMUNERATION DETERMINATION AND CONTINUOUS OPERATIONAL IMPROVEMENT

A job can only be remunerated as piecework if it meets the following requirements:

- Piece-rate capability can be assumed if the process is
  - well-known beforehand,
  - homogeneous,
  - regular with sufficiently recurring patterns and
  - can be easily and precisely measured.
- Piece-rate maturity can be assumed if the operating sequence is free of flaws,
  - the workers deployed are well-trained and have sufficient experience to have adequately mastered the tasks.
- The employee must be able to directly influence his or her workload.

Since the number of workplace activities that meet these requirements is in decline, piecework will become less important in the future!

Particularly in serial production where employees can completely or by and large control their work (e.g. assembly operations), piecework wages is a suitable type of remuneration.

The advantages are:

- wages according to performance,
- strong performance incentives, high productivity,
- key performance indicators can be further used for planning, control and calculation purposes,
- simple performance evaluation by superiors.

Significant disadvantages are:

- only one performance characteristic, no incentives for improvement of machine utilization, quality or in savings of material,
- no upper limits, ´runaway production`,
- minor improvements (creeping rationalization) do not lead to an adjustment of target times,
- high costs for data collection and payroll accounting,
- not suitable if the share of restricted work increases.

The most important requirement for a functioning piece work system is the constant maintenance and monitoring of the target times.

3.1 Renumeration

Requirement and performance related determination of wages

Employees are compensated for their work in the form of **income**. This income is a **cost factor for the company**.
An appropriate level of wages is very important for the economic success of a company as well as for worker satisfaction although there is no universal optimal wage level for every company.
The setting of wages is primarily based on the relationship between worker productivity and wage levels. Two fundamental principles should be adhered to:

- Wages should be appropriate to the work being performed which means that wage levels should correspond to the objective requirements of the worker's position
- Wages should also be **performance related** which means that they should reflect the individual performance of the worker.

Wage levels should therefore depend on:

- **What** the work to be done is (independent from the influence of the employee) which means what kind of work is to be done, its level of difficulty and the qualifications required to perform the work.
- **How** the work is to be done (influenced by the worker) which refers to the levels of individual performance such as work quality, speed and quantity.

Wages are usually determined by considering **three components**:

- Negotiated base wage (dependent on wage group and/or value of the position),
- Negotiated work load (dependent on the performance of the worker and/or work group),
- Extra pay/benefits (dependent on operational conditions).

A total wage is determined as follows:

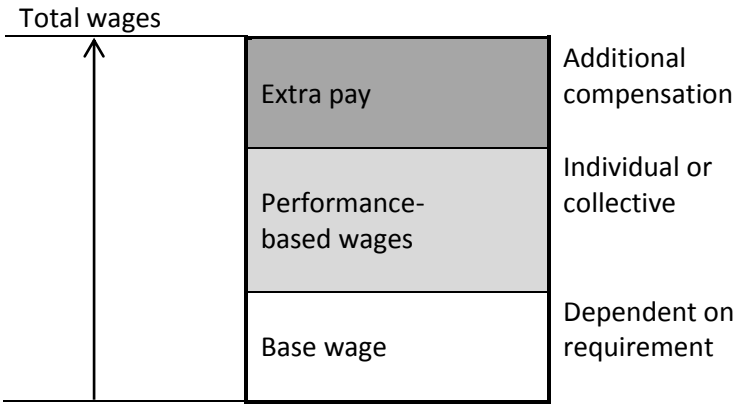


Figure 3.1: Basic wage structure

The **requirement-based differentiation of base wages** is carried out with the help of a **job rating**. This means that either a **non-analytical job evaluation** with wage group classification or an **analytic job evaluation** should be carried out. An analytic job evaluation means that the job valued of various positions are determined without regard for who is filling the positions.

Performance based wage differentiation is based on the performance levels of individual workers or working groups. This is carried out either through a contractually agreed upon **performance assessment** based on fixed criteria or by determining **performance statistics**. In this case, various actual performance results of individual workers or groups of workers are usually compared with predetermined target numbers with time playing the most important role in the comparison.

3.2 Types of wages

Several different forms of compensation have developed over the years reflecting various considerations:

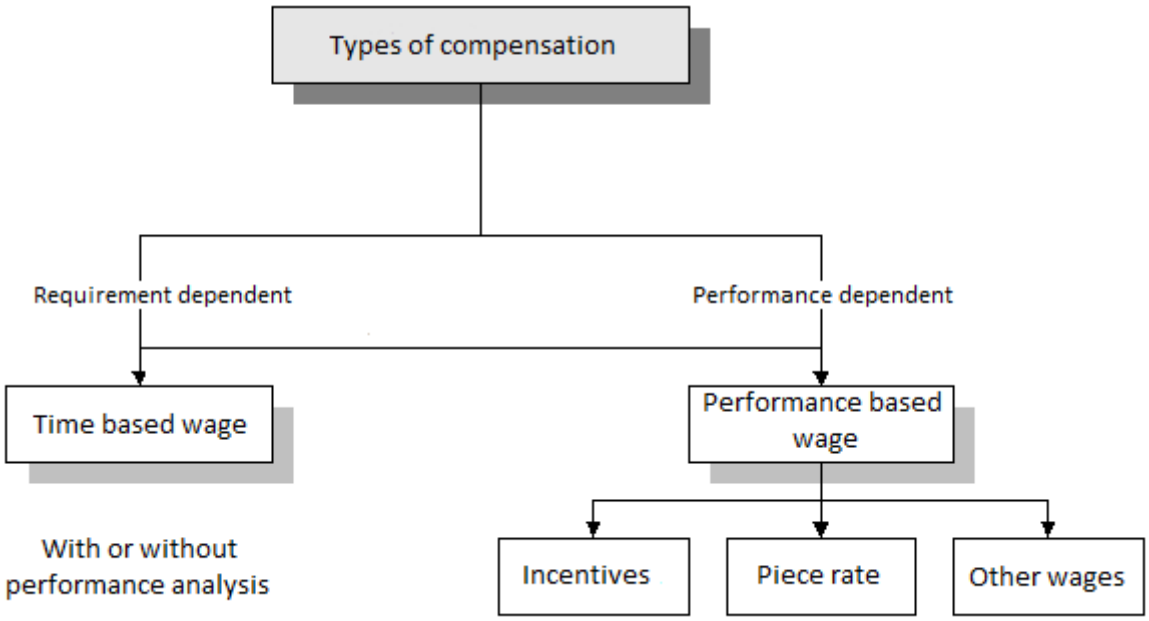


Figure 3.2: Type of compensation

3.3 Time-based wages

Time-based wages offer a fixed compensation based on a defined unit of time (e.g. fixed hourly or monthly wage).
In its simplest form, the level of **time-based wage without a performance analysis** is determined only by the position's work requirements. Variations in the individual performance of workers is not taken into consideration even though it is clear that certain levels of performance are to be expected.
This pure time-based wage is seldom used.

Time-based wages with a performance analysis are far more common.
In this case, the base wage (as in all forms of compensation) is determined by the requirements of the position but an additional bonus will be awarded based upon the results of periodic performance assessments.

The **performance is not determined quantitatively** in the sense of work performance being defined as the relationship between the work results and the working time. A much more common method is a qualitative assessment that is carried out periodically (e.g. yearly) by the worker's superior based on concrete assessment criteria which will measure the degree in which the work was completed The assessment process and the related criteria are usually contractually defined.

Example

In the pay scale region of North Rhine-Westphalia, the metal and electrical industries carry our performance evaluations based on the following system:

Surname: ..... First name: ..... Personnel # ..... Dept.: .....
was assessed an incentive bonus of ..... with the following results: Work value: ..... Work#: ..... Entry on: .....

	0	2	4	6	8
Work results Performance based on intensity and effectiveness	Performance ineffective	Performance not yet completely effective	Performance effective	Performance very effective	Performance excellent
Workmanship Quality by adherence to the relevant quality work methods and manufacturing instructions	Many complaints	Still too many complaints	Some complaints	Few complaints	No noteworthy complaints
Work flexibility Assignment to various tasks	Can only be assigned to very limited tasks	Can be assigned to limited tasks	Can be assigned to a variety of tasks	Can be assigned to a wide variety of tasks	Can be assigned anywhere
Work diligence Professional handling of materials, frugal use of tools, energy, auxiliary materials, adherence to safety regulations	Unprofessional handling	Handling is not yet professional	Professional handling	Diligent and well thought out handling	Excellent handling

Bonn-Bad Godesberg, on ..... 20..... **To be filled out by PVLL:**
....
– The Assessor – – The assessor's superior – Total points: ..... x Factor: ..... = ... %
Pers # ..... x Work wage ..... = Performance bonus: ..... €/Hr.

The assessment was discussed with me. Wage is effective starting: .....
Date: .....

Bonn-Bad Godesberg, on ..... 20..... Information shared with worker and VDV.
.....
....

– The assessor – – The assessed – Date – Administrator PVLL –

Figure 3.3: Assessment card for time-based wages

The **advantages of time-based wages**

- Simple wage determination and simple salary calculation
- Fixed wage level for long periods of time
- No reduction in quality

There are also **disadvantages**:

- no real incentive to produce, no incentive to increase productivity
- low performance fairness,
- Performance assessment id not completely objective

With time-based wages, there is no direct relationship between the wage level and work performance. The worker will be expected to produce at a reasonable level that is determined by the volume of work the position is expected to handle or by an individual discussion with the worker's superior.

Time-based wages are most commonly used in auxiliary and service areas in areas close to production (e.g. storage, transport, inspection, handwork) or other general

3.4 Piece rate

As opposed to time-based wages, **piece-rate wages** offer a direct and proportional relationship between the worker's individual level of performance and the wage level

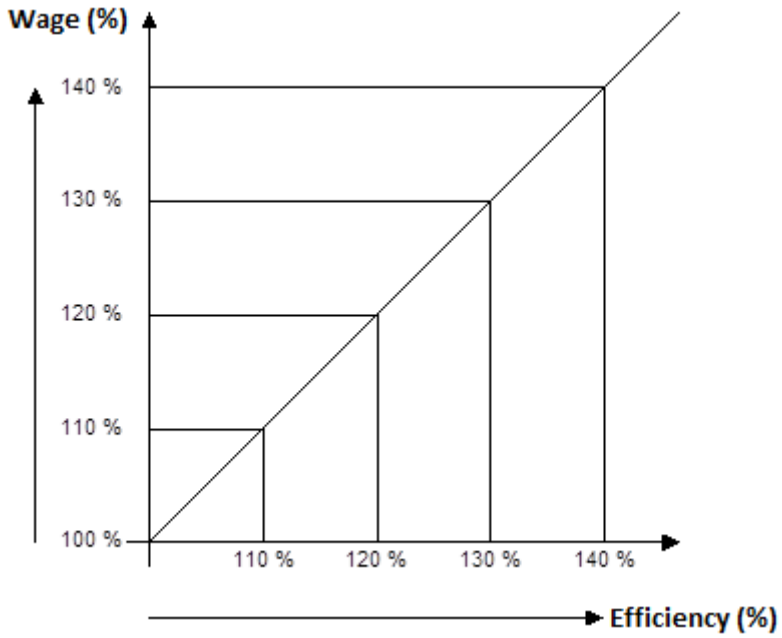


Figure 3.4: Piece-rate wage graph

With a piece-rate wage, the worker's wage changes in the same degree as his performance even though the wage level can continue endlessly upward. The efficiency rate is used as a performance indicator which is determined by the quantity of work performed.
The determination of the efficiency rate requires projectable work procedures with target times.

Example

A production facility making products to order, receives an order for 60 molded parts. The target times are: *te* = 5.2; *tr* = 45

The worker completed the order in 4.5 hours. This results in the following:

Efficiency $= \frac{Target\ time}{Actual\ time\ needed}$ x 100

$= \frac{60\ x\ 5.2 + 45}{270} = \frac{357}{270}$ = 132 %

The worker earned 132% of the piece-rate wage. However, this calculation is usually made periodically (e.g. monthly).

The following then applies:

Efficiency $= \frac{Total\ target\ time\ (per\ period)}{Total\ time\ needed}$ x 100

3.5 Premium wages

Premium wages, just like piece work wages, is a type of incentive wage, which meets the demand for payment according to effort and performance.
However, with premium wages other performance factors, aside from quantitative output, can be considered.

The main types of premiums are:

- quantity premiums (reference characteristic is quantity or time)
- utilization premiums (reference characteristics are, for example, equipment utilization, machine downtime, setup time)
- quality premiums (reference characteristics are, for example, yield, scrap, rework)
- saving premiums (reference characteristics are, for example, material usage, energy consumption, indirect production costs)

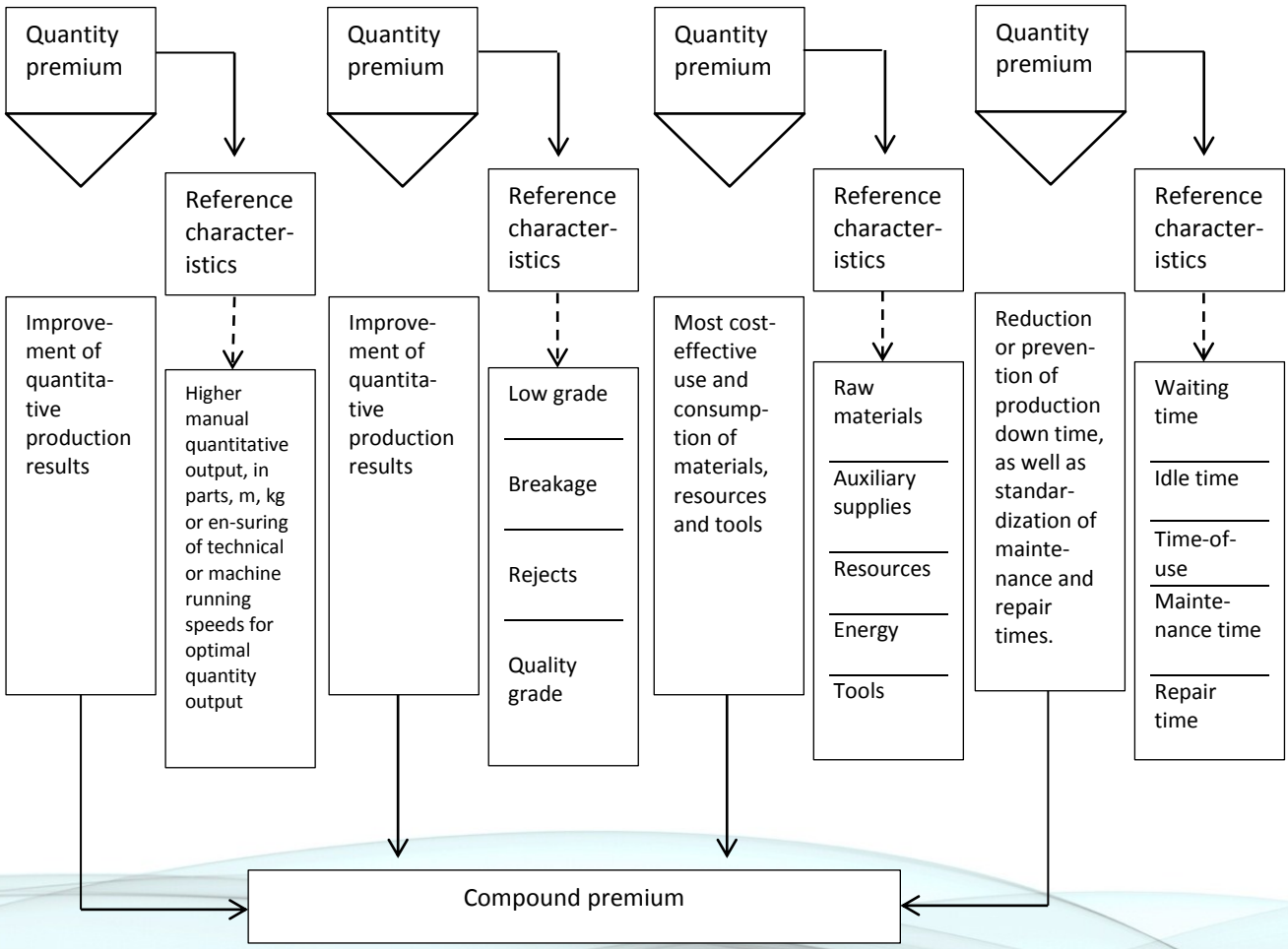


Figure 3.5: Types of premiums and their reference characteristics

Compound premiums can be used as combinations of different types of premiums

Which type of premium is most appropriate depends primarily on the respective production process:

- To what extent can the employees influence the production results?
- How large is the variation of the different reference characteristics (or key performance indicators)?
- Which process objectives (derived from the company objectives) are paramount?

Example
The production department of an industrial enterprise in contract manufacturing has been using piece work wages for years.

Due to market changes (smaller batch numbers, shorter shipping times, more frequent changes in the production schedule) and the introduction of new technologies (CNC-tools), there were, in part considerable, changes in working methods and conditions. Changes in the volume of work and the degree to which workers could influence it, led to uncertainties in target time determination and ever increasing labor utilization rates.
To reduce pay inequality for differing shares of time which cannot be influenced and to prevent further uncontrollable increases in wages, the form of remuneration was changed to quantity premiums, while the target time as reference characteristic was kept.

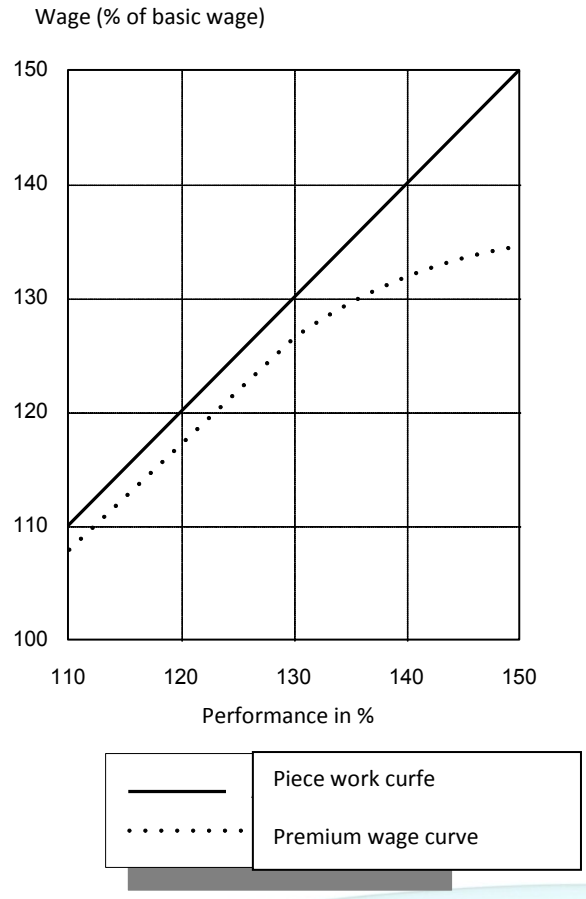
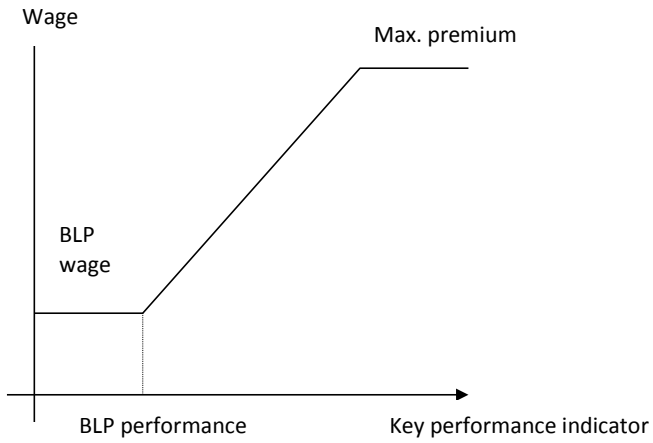


Figure 3.6: premium wage curve

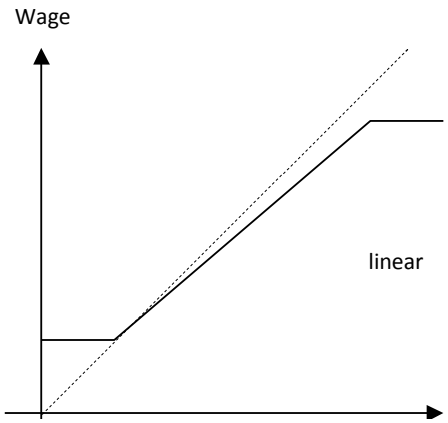
Premium wage is based on a basic level of performance an employee can be expected to meet under normal circumstances and is remunerated with a basic wage. Increased efficiency leads to higher wages according to a preset wage curve.
The wage curve shows the relation of wage level to the corresponding key performance indicator.

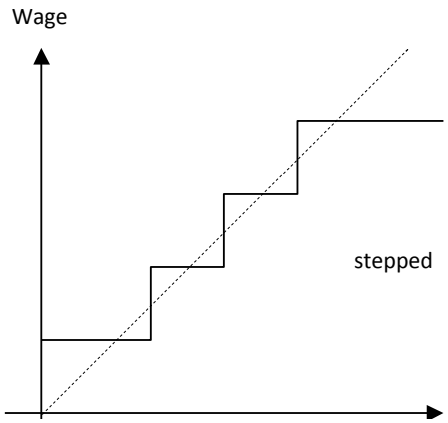
The simplest form is a proportional wage curve, resembling the piece work curve, except for it usually being capped.



BLP = basic level of performance
Figure 3.7: Proportional premium wage curve

The appropriate progression of the wage curve for each individual case depends primarily, as with the types of premium, on the production process and business objectives.
Illustration 16 shows more, typical premium wage curves.





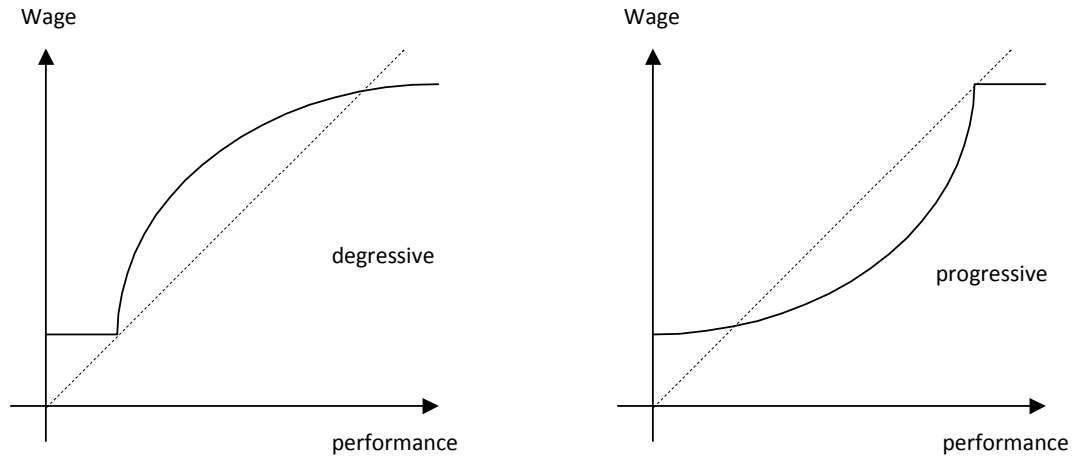


Figure 3.8: Typical premium wage curves

For linear or stepped premium wage curves an increase in performance is accompanied by an even increase (over-proportionate = higher, under-proportionate = lower) in wage level.

For degressive curves the premium increases less and less with increasing performance. For progressive wage curves, on the other hand, performance levels in the peak range are more strongly rewarded.
Combined premium wage curves could also be considered, e.g. progressive development for lower performance levels (incentive for quickly reaching the target performance level) and degressive development for higher levels (further increase in performance hardly worth it).

Premium wages have significant advantages:

- broad application range, customization for different departments and special operating features possible,
- takes performance into account, can take more than one performance characteristic into consideration,
- performance-based remuneration, even where piece work wages are not possible,
- wages can be capped,
- key performance indicators can be used for planning, control and calculation purposes.

But there are, nonetheless, disadvantages:

- cost of data collection and accounting is relatively high,
- ongoing monitoring of key performance indicators is necessary,
- relation of wage level and performance results is not always clearly discernible.

One of the main features of premium wages is the variety of design options.

3.6 Selection of remuneration type as control instrument in businesses

The choice of remuneration type influences the payroll costs of business with regard to the amount as well as structure (fixed and variable costs).
In addition, it naturally has an influence on employee motivation (= willingness to perform).

Table 3.1: Comparison of the most important types of remuneration

Types of remuneration	Time wages	Piece work wages	Premium wages
Hourly earnings of employee	Constant	Varies, depending on employee performance	Varies, depending on achievement of premium reference values
Income risk for the employee	Lowest	Highest	Present, no guarantee of income
Remuneration of increased efficiency	None, if no incentive bonus has been agreed upon	Direct remuneration, linear in direct proportion	Indirect remuneration, dependent on premium wage curve - linear - over-/under-proportional - progressive/ degressive
Incentive for increased performance of employee	Little, without incentive bonuses beyond the basic wage	Direct	Indirect
Costs per part	Increase or decrease proportionally to the time required, depending on exceeding/not exceeding target time	Constant	Varies, depending on achievement of premium reference values
Calculation certainty/risk for employer	No calculation certainty; risk	Calculation certainty, no risk	Limited calculation certainty, low risk

4. INNOVATION AND CONTINUOUS IMPROVEMENT PROCESSES

4.1 Methods and tools of a continuous improvement processes

The necessity of operational improvements has been sufficiently established in the previous sections. Up to now, a variety of methods and tools for their implementation have been established and thoroughly tested. Among these are Six Sigma, 5S, FMEA (Failure Mode and Effects Analysis), SPC (Statistical Process Control), BSC (Balanced Scorecard).
These all adhere to the principle of a systematic approach according to the PDCA-cycle.

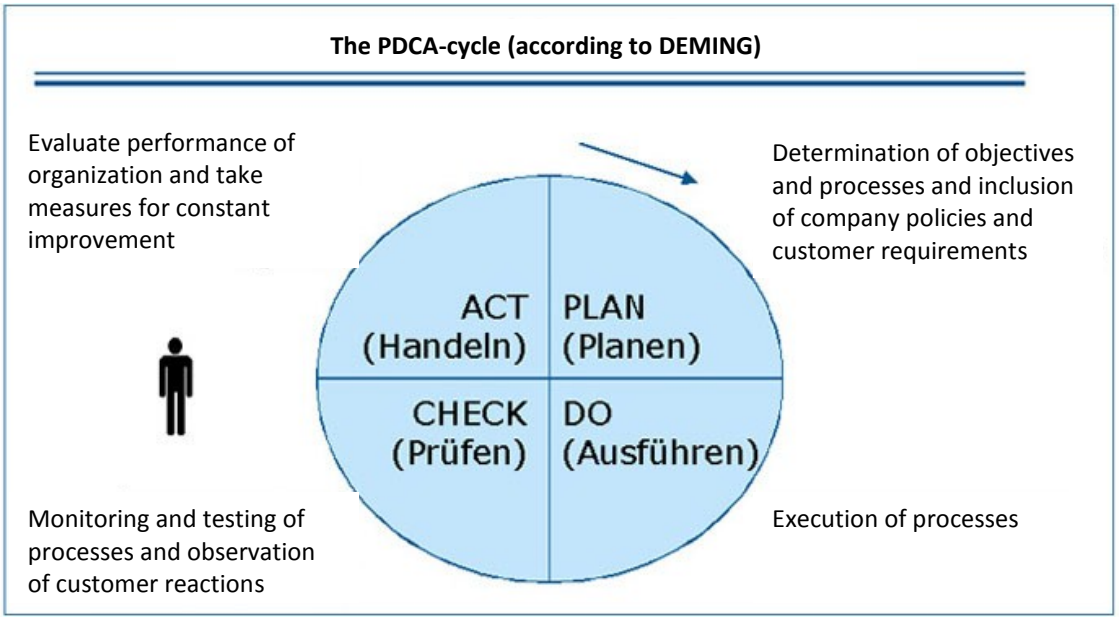


Figure 4. 1: The PDCA-cycle (according to DEMING)

The PDCA-cycle according to DEMING

- **Plan:**
  First the current state is described – in the form of data, as far as possible – and the obvious problems deduced. Based on this data, the target state is defined. Then a cause analysis is conducted and, based on this, possible proposals for solutions collected. These proposals are reflected and refined on obstacles over several loops until they are workable. Finally, the package of measures is tied up and it is decided who does what by when (to-do-list).
- **Do:**
  The selected solution is implemented on a trial basis.
- **Check:**
  Following the implementation, it is tested – also in measurable facts, as far as possible – whether the new procedure is an improvement over the old one.
- **Act:**
  If this is the case, the new procedure is made generally binding and the employees are trained accordingly.

This shows that PDCA comes very close to the DMAIC from six-sigma, which also provides a problem solving guideline. The most important and common methods or procedures are briefly characterized in the following chapter.

4.2 KVP as an essential element of innovation

4.2.1 Methodology of benchmarking

Benchmarking, in the sense of ´learning from the best`, is now wide-spread in Germany.

Definition: Benchmarking
= a methodology which sets the best practice a company can find for individual performance activities within its own value chain, within its business sector or even without, as a target (benchmark) to be reached or surpassed.

Generally, a distinction is made between open and covert (not discernible by contracting partner) benchmarking.

a) The benchmarking process
(following FB/IE 47 1998/1 - ´Benchmarking – ein Weg zur Produktivitätssteigerung`)

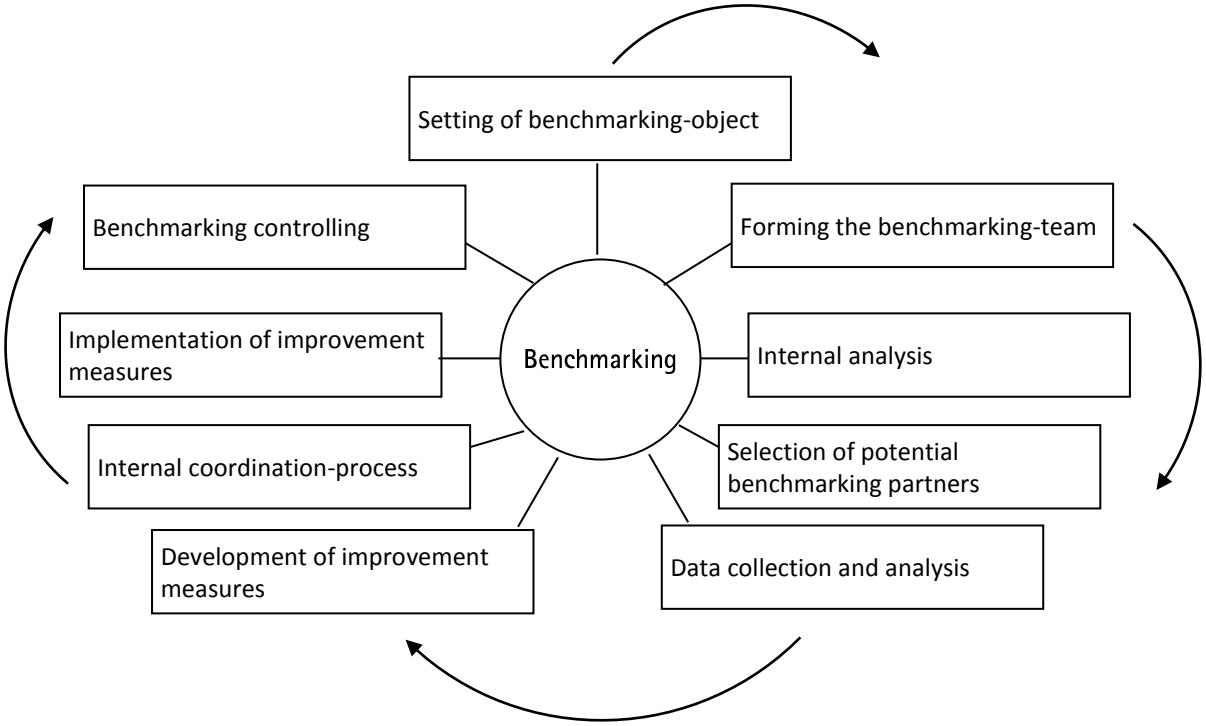


Figure 4.2: The benchmarking process

- **The setting of the benchmarking-object**
  Follows the preferences (= critical success factors, potential weaknesses) expressed by internal or external customers;

- **Forming the benchmarking-team**
  Preferably full-time members who are experts with sufficient authority over line functions;

- **The internal analysis**
  Processes related to the benchmarking object are fully documented;

- **Selecting benchmarking partners**
  Commercial consulting companies, specialized in brokering suitable partnerships, now exist;

- **Data collection and analysis**
  Is conducted as in any other type of classic organizing project, yet requires the partner to agree on shared definitions and comparable procedures;

- **The development of improvement measures**
  Also involves the determination of performance gaps and definition of the future performance level to be aimed at;

- **Internal coordination process**
  The measures for improvement are conjointly decided upon;

- **The implementation of improvement measures**
  Also involves familiar procedures, already known from traditional organizing projects;

- **Benchmarking controlling**
  Monitoring of the progress of the optimization process and the achievement of objectives shows whether the improvement measures are successful;

b) Potential errors during the execution of the benchmarking process

As clear and simple as this methodology may appear, the practical implementation has typical errors showing up again and again:

- **Selection of unsuitable or too many benchmarks**
  The method of critical success factors is well suited to truly identifying the most appropriate benchmarks; only simple and significant key indicators should be considered.

- **Wrong choices for filling positions in the benchmarking team**
  Here the technical expertise of the employee is of utmost importance. Unfortunately, in practice, the individual availability for (if possible full) release from their technical department is given precedence. A blend of employees from staff and line departments, external consultants with company, sector and method competence is essential. To improve acceptance the, at least temporary, inclusion of the workers' council should be considered.

- **Collection of an unmanageable amount of data**
  The focus of the benchmarking process should always be the interpretation of data and the derivation of corresponding measures. Too much data shifts the focus to data collection and makes the filtering of important data difficult. It is empirically known that the determination of even the very last bits of information requires an unreasonable expenditure of time and money (´80-20-rule` or ´Pareto-principle`)

- **Uncertainties in the selection of suitable benchmarking partners**
  Determining the ideal company for comparison poses a great problem. It requires knowledge of global ´best-practice-solutions`, observance of the economic, cultural and political circumstances under which these solutions were implemented and access to the decision makers of the identified company. In addition, a too large performance differential between the companies might frustrate one's own employees and paralyze efforts to improve (= close the discovered performance gap). Therefore, the claim ´learning from the world's best`, should realistically be rephrased as: ´learning from someone a lot better`

- **Poor communication and integration of employees**
  Poor integration of the employees affected leads to an atmosphere of rejection; employees must be informed as comprehensively as possible about: objectives, methods, procedures and results.

This can not be summed up better than by the authors (Carsten Braue, Matthias Sure) of the article above:
´A benchmarking project can be a humbling experience, but humility or the belief that products and services can always be improved is what separates winners from the mediocrity`.

4.2.2 Formation of company advisory boards

Another method is the formation of so called company advisory boards:
These consist of appointed experts who regularly meet at the company to contemplate trends in the societal and economic environment of the company, and in particular, to initiate changes. The members of this advisory board come from the field of higher education, the consultancy sector or even (of special importance!) the company's circle of customers. Over time a core membership arises, supplemented by rotating additional members. Additional members from the circle of dissatisfied customers are especially welcome, because these are particularly well qualified for giving information about and making constructive suggestions for processes and product characteristics that have caused their complaints. An additional benefit for the company is the fact that dissatisfied customers whose concerns are taken seriously and who note the supplier's will to improve often become especially loyal regular customers!

4.2.3 Systematic observation of technology

Companies must recognize changes and developments in technology as early as possible, i.e. they must be sensitive to (key) technologies at the beginning of their life cycle.
If a company has significant know-how in a chosen technology segment, it has to keep this lead on its competitors as long as possible or even expand it; in addition it should remember to substitute the respective technology in time. If a company has shown little core competence in the chosen technology segment, it must not miss the trend and must be ready to follow it before the technology gap becomes too big to bridge over.

Technology drivers are science, problems with existing technologies, fashion developments, cost developments and changes in legal conditions.

The information usually reaches the company at first through informal channels, at trade fairs, in work groups (association committees), sector-specific boards (standards-) and, unfortunately, all too often just remain unnoticed by the heads of the employees involved.

It is also necessary to permanently monitor publications for suggestions useful to one's own company (scientific journals, patent publications); such an interdisciplinary early-detection-committee needs experienced and competent employees, mostly from the management level.

4.2.4 Conjoint-analysis

This methodology serves the anticipatory and/or retrospective determination of customer preferences and expectations.

These mathematically-statistically very sophisticated models attempt to determine the value of product characteristics and their expressions (and potential combinations thereof) through solution algorithms.
Based on these, the R&D-activities can be configured, oriented towards specific goals.

4.2.5 Quality circles

Quality circles and similar approaches (learn shops) follow the principle of inter-meshed groups.

Such institutionalized small groups meet more or less regularly, under guidance of a moderator to uncover weakness in their own (or predefined) areas of responsibility and find potential solutions for them.

The basic idea, which originated in Japan, is to get the collective to actively make changes (i.e. improvements) and not to wait for an actual need for change to arise, for example, through economic difficulties or defective products. Its rapid spread was ensured by the deeply rooted need for harmony in Japanese society and culture.

Before establishing quality circles a few project-related institutions have to be created:

- The steering committee is the highest decision-making body which determines the installation and objectives of quality circles and the final realization of suggestions.
- The steering group manages potential conflicts between work groups and is responsible for the implementation of suggestions for improvement.
- The coordinator trains the moderators and assigns experts to support the groups and coordinates the individual circles.
- The moderators (ideally the immediate superior of the group members) directly manage the work of their circles.
- The quality circle groups are formed on a volunteer basis; all members belong to the same organizational unit or have similar or related tasks.

Related to this topic, an excerpt from PLATTFORM, the company magazine of the Veba Oel AG (2/98):

´Reliability Improvement Program` in the Gelsenkirchen plant group

´Over the last years there have been multiple unplanned system standstills in the Gelsenkirchen plant group – in particular in the Olefin-system. There were a variety of causes. The ´Reliability Improvement Program`, which has been running since September 1997, is supposed to consistently improve system reliability.
(...) If we improve our value creation process, we improve the results to satisfy our customers. Our most important goal for 1998 was declared to be achieving an equipment availability rate of 98 % - the average for Western Europe is about 94 %.
... the reliability-consultants ... as well as Linde AG support the WGG-team. ... The results for the maintenance process are mixed: the high level of expert knowledge and the strong inspection ethics was seen as very positive. Not as good: the maintenance process was impeded by too many unplanned tasks and too many interfaces.
... For every one of the identified deficits the plants and specialist departments, together with ... and the reliability-team developed suggestions for improvement, which as the next step now will be implemented in the form of a pilot phase in the Olefin 3-system. This ensured that ideas and change requests of employees could be taken into consideration at an early stage...
... Over the next months further studies are scheduled – that is for the mineral oil system. This will affect an even greater number of employees ... The ... team would like to heartily invite all employees to share their knowledge and experience to promote this program.`

The following is part of the ´reliability-program`:

- Identification of the equipment- and system-influences, which are critical to the availability of the process-system;
- Maintenance and down-time: strategy and process (task-selection, -preparation and execution);
- Process organization in production, maintenance and planning (minimization of intersections);
- Quality management and control of operational, maintenance-related and down-time processes;
- Technological improvements of the systems;
- Continuous evaluation of the state of the process-system, e.g. the remaining runtime

The goal of constant improvement in all areas is often aspired to under the title of ´Kaizen`, the constant effort to achieve a continuous improvement process (CIP)(kai = change, zen = goodness). Following the Japanese ´ringi-system`, this involves integrating as many of those affected as possible in the decision-making-system.

These quality circles employ various creativity techniques to find creative solutions for problems. The following table shows a comparison of these creativity techniques.

Table 4.1: Comparison of significant creativity techniques

Characteristic \ Method (originator)	Brainstorming (Osborn 1963)	Synectics (Gordon 1961)	Morphological analysis (Zwicky 1971)
General characteristics	Techniques for gathering creative ideas spawning of suggestions or problem solutions through free association and creation of analogies		Method of discursive idea creation (recombination of established data)
Maturity of ideas	Preliminary suggestions	Complete, even physical-constructive problem solutions	Relatively complete theoretical model
Complexity of potential problem solutions	Relatively low	Suitable even for very complex technical problems	
Group composition and procedure	Group of four to seven members; professionally homogenous composition, if possible; qualified leader and recorder necessary; duration approx.15-60 minutes	Group of five to seven members, that should be trained in synectics; qualified leader and whiteboard necessary; duration approx. two hours	Any size, even a single person; subdivision of overall solution into several parameters of variable expression (partial solutions)
Distinguishing features	No hasty criticism during idea production; free associative interplay of thoughts within the group; prevention of social tension; goal: large number of ideas, from which useful solutions arise	Intensive familiarization with problem; disassociation from original problem through analogies from other areas; reconnection with original problem provides clues for innovative solutions	Run-through of all the combinations of characteristics in the Morphological Box (or Matrix). Useful solutions are determined based on problem-related assessment standards.

- **Association techniques**
  Association techniques are based on letting one's thoughts run free and thinking unconventionally in every direction. By recombining thoughts and ideas in new ways, one receives a multitude of concepts (approaches), which then can be further developed into potential solutions. One can distinguish the following techniques:
  - Brainstorming
  - Brain-writing
  - Mind-mapping
  - Combined techniques
- **Visual and analogous based techniques**
  Analogies are similarities, i.e. solutions by themselves that initially do not seem to fit the problem, but might contain the (seed of a) solution:
  - Visualization
  - Bisociation
  - Emotive-word-technique
  - Intuition

- **Systematic search for ideas**
  The systematic search for ideas is based on structure, i.e. based on various checklists the problem is examined from different perspectives:
  - Morphological Matrix
  - Osborn-method
  - Reversion method

4.2.6 Six Sigma

What is the Six Sigma approach?

- As corporate philosophy Six Sigma consistently focuses all employees on customer orientation and financial results
- As key indicator Six Sigma signifies a strategic and entrepreneurial orientation; this allows the performance of processes to reach a rate of only 3.4 defective parts per million opportunities.
- Six Sigma allows the implementation of measurable improvements to be achieved in only a few months time. Here focusing on the essentials is supported by the Six Sigma organization methods and the so called DMAIC project-cycle, which is similar to the PDCA-circle (Plan-Do-Check-Act). Only in 5 phases, instead of 4: Define – Measure – Analyze – Improve – Control.

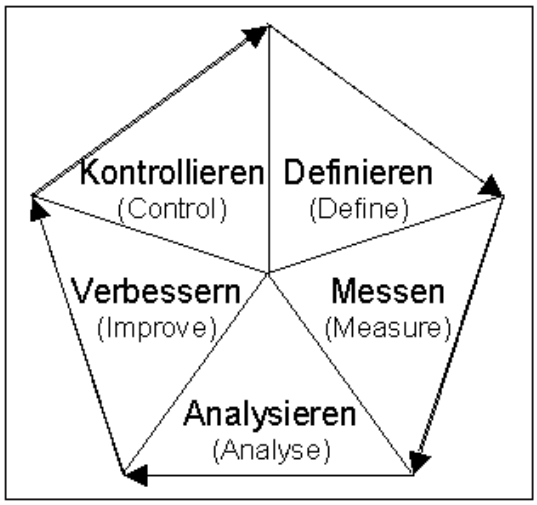


Figure 4.3: Six Sigma approach

1. A problem within the product or process chain is defined.
2. Using various statistical tools, its magnitude and impact are measured and
3. Analysed
4. The resulting improvement measures are then consistently implemented.
5. The effectiveness of these measures is then checked, before the next problem is targeted.

Various problems are defined, until the zero-defects-quality of Six Sigma is reached.

4.2.7 The S-approach - ´Housekeeping`

is a method of systematically and sustainably organizing the workspace. Its goal is to improve performance quality and throughput time of individual tasks, through good order and cleanliness in the workspace.

By adhering to the 5S
- Sorting
- Systemizing
- Sweeping
- Standardizing
- Self-discipline

unnecessary ballast and waste of time is reduced and employees can focus on the essentials.

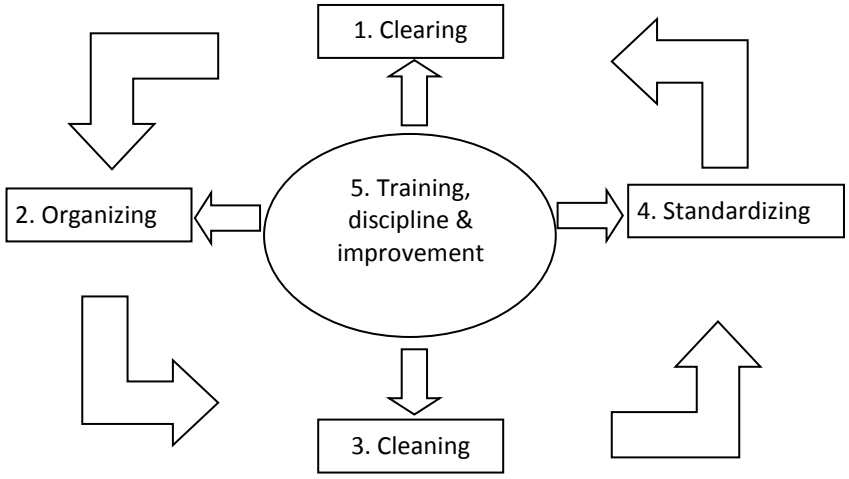


Figure 4.4: 5S-model

4.2.8 FMEA (Failure Mode and Effects Analysis)

The method of Failure Mode and Effects Analysis (FMEA) was developed in the sixties for air safety investigations and later also used for space travel, chemical plants and automobile development. Since the accident at Three Mile Island it has also been applied to nuclear facilities.

FMEA is an inductive method of analysis, which is used to assess the potential effects of the failure of individual components of a system. FMEA begins with the knowledge of failure modes of individual components and examines the effects of each failure on subsystems, as well as the overall system. It involves the examination of every component of a system and is frequently used for higher system levels or even on plant levels. FMEA checks whether the components and their known fault potential meets the safety requirements of the corresponding (or possibly the next higher) system level.

1. **Structural analysis:**
   Structural analysis involves
   - division of the FMEA object into its individual elements,
   - clearly differentiating the object from its surroundings and
   - clearly differentiating the elements of the object from each other.

   The VDA 1996 recommends the structure tree as tool for the hierarchical division (or block- or flowcharts).
   Structural analysis also identifies the elements of the object, relevant and irrelevant to the overall analysis.

2. **Functional analysis**
   Functions and connections of the relevant elements of the object, as identified by the previous step, are determined; this is a preliminary step for the later development of error prevention mechanisms (error cause -> error -> error effects), which, of course, have to follow the functional pathways.

3. **Error analysis**
   The functions, specified in the previous step, determine the types of malfunctions. The malfunctions of the relevant elements of the object become the potential errors of the FMEA, since (according to VDA 1996) malfunctions also derive from functions of elements relevant to error causes and error effects. They form the basis of the subsequent mapping of error causes and error effects to the respective potential errors.
   Another component of the error analysis is the mapping of error causes and error effects to the previously determined potential errors (malfunctions of relevant elements of the object), conveniently in a so-called failure net, which reflects cause-and-effect-relationships, as are present between error causes and errors, as well as between errors and error effects.

4. **Risk assessment (for the current state)**
   Each fault mechanism (beginning with the error cause) is assigned a key indicator (integers in the range of 1-10) for likelihood of occurrence (O-value), detectability (D-value) and severity (S-value).
   Under consideration of prevention and detection measures, risk priority numbers (RPN) are formed.

5. **Risk minimization**
   Based on the risk assessment of the current state improvement measures are sought for the fault mechanisms in descending order of their RPN- and individual values. For each proposed/arranged measure
   - a responsible person,
   - a (scheduled or actual) completion date and
   - the current state (unprocessed, in process, completed, dismissed)

   are determined and monitored.

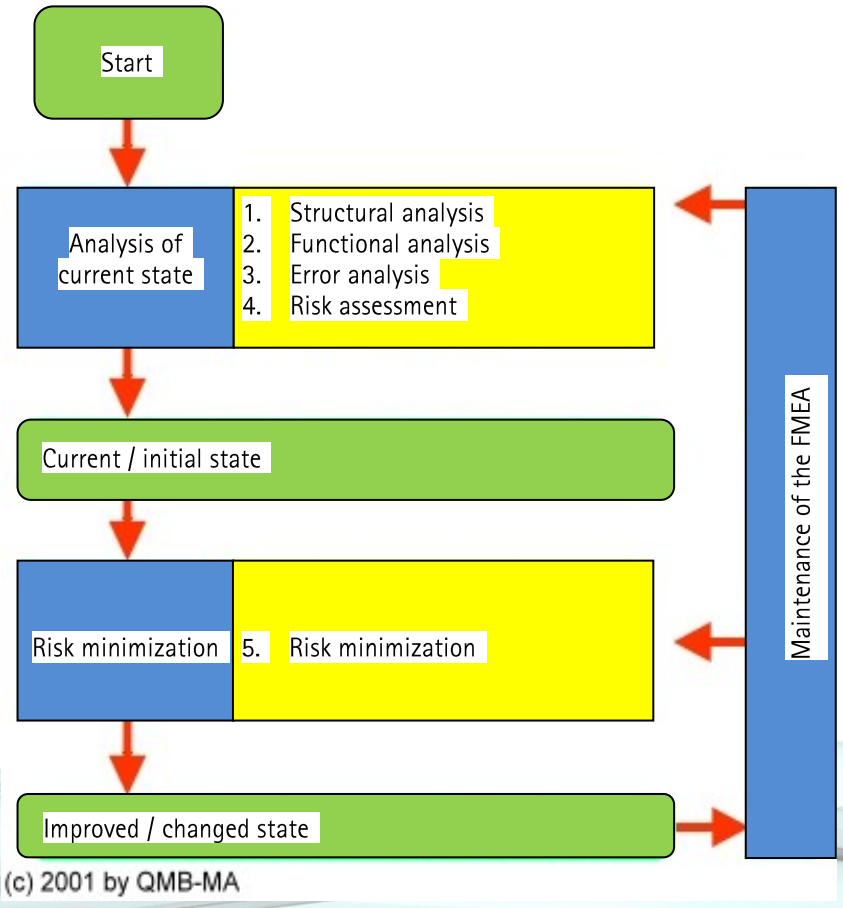


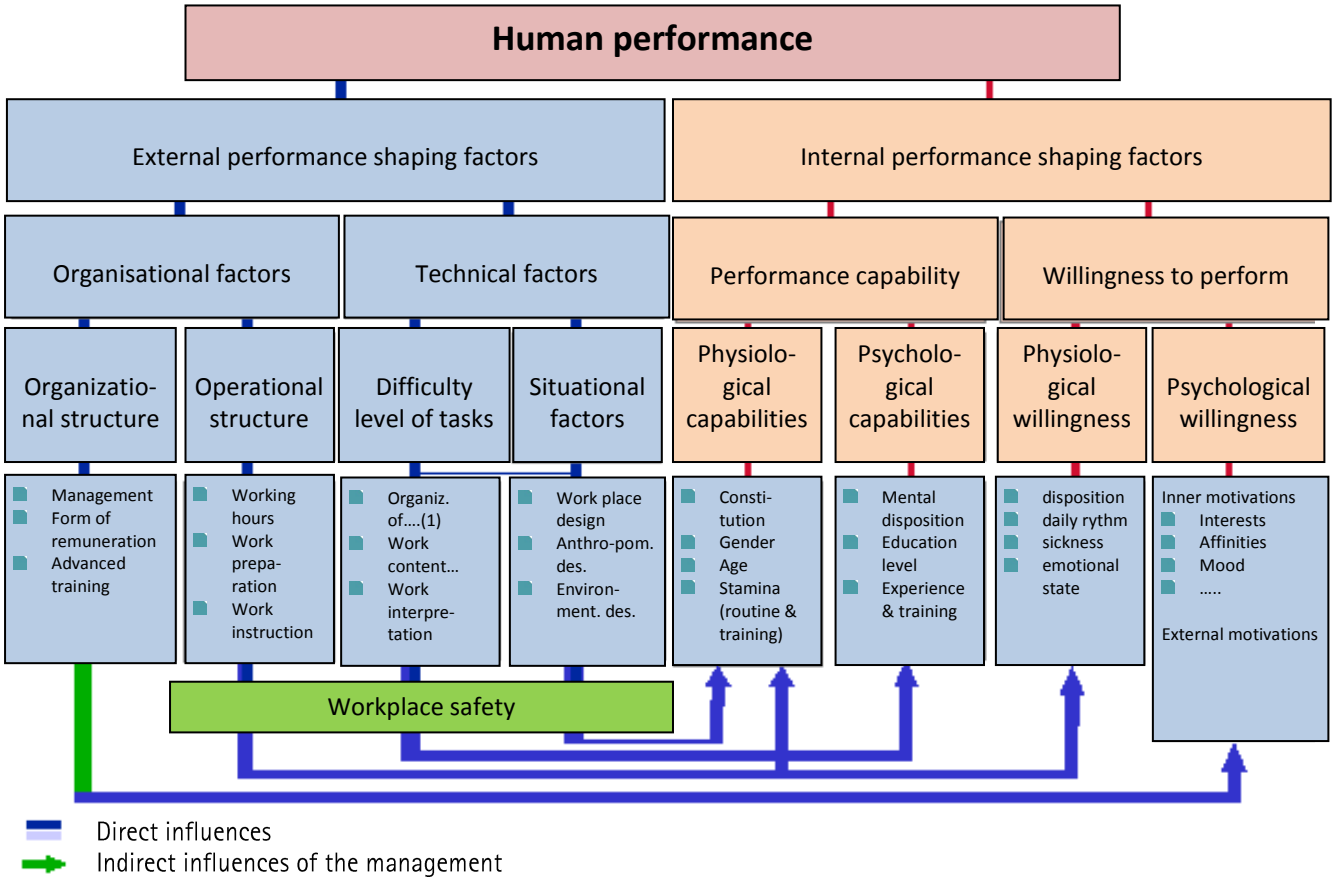
Figure 4.5: FMEA-process (see also VDA 1996)

4.3 Aspects of ergonomic work design

Company work is the execution of certain work items for the achievement of company goals. Traditionally, (since Gutenberg) it has been divided into

- directive work (leading, planning, managing): what today would be called ´management tasks`; and
- executive work

Work-performance is the work-result of a work-system relative to a certain amount of time. It is the result of the human performance range (as determined by performance capability and willingness to perform) conforming with the performance requirements of the company.



(1) Organization of equipment and material distribution

Figure 4.6: Factors influencing work performance

4.3.1 Focal points of work design

The purpose of work design is to provide the conditions to allow productive interactions between people, technology, information and organization within a work system. The goal is to accomplish the work tasks, while taking human characteristics and needs, as well as the economic efficiency of the system, into consideration.
The objects of work design are work systems. Therefore, it is sometimes called system design. If the object is a single work space it is called work space design, in the case of multiple connected work spaces it is called work flow design.

The optimal design of the work flow requires a detailed analysis of the operational sequence. This includes the design of material flow and the linking of separate work spaces into an overall system.

This section mainly focuses on the requirements and design measures of work space design in the narrower sense of the word.

A work space is the spatial area in a work system, in which the work task is performed.
The goals of any work design project – ergonomic work spaces and work flow, as well as efficient operational organization – can only be achieved, if all elements of a work system (enployees and equipment, work tasks, work flow and working conditions) are considered as whole and factored into the design measures.

This leads to the following focal points of work design:

- Design of work spaces and equipment under consideration of
  - anthropometric
  - physiological
  - IT-related
  - mobility-related
  - safety-related conditions.
- Design of the work environment regarding climate-control, noise, lighting and color.
- Design of the work flow regarding working hours, breaks, shift work and work structure.

There is a strong connection between the suitability of the work spaces for humans and the technically and functionally correct flow of work.

Work design oriented towards humans will, in most cases, lead to an increase in efficiency.

A holistic approach to works systems under consideration of humans, technology, data and organization requires a systematic and step-by-step course of action. The methodical and step-by-step approach, as will be briefly presented in the following, has proven itself for operational design measures.

4.4 Suggestion systems – evaluation of suggestions for improvement

As mentioned in the beginning, a company is subject to various environmental influences.
It needs to adapt to these influences through constant changes; or even better, it prepares for these changes in advance. Ideally, a company even actively shapes this process of changing, substituting the reactive role and becoming active.

All employees are called upon to help in shaping this process, so that they do not have to live with changes others have provided for them! Not just a few ´change managers` should be responsible for the advancement of the organization and its staff, who then have to enforce the necessary developments, possibly against significant resistance.

4.4.1 Definition and delineation of the classical ´suggestion system`

Obviously there is no legal requirement for employees to actively participate in the suggestion system of their company. Then again, the establishment and maintenance of a company's competitiveness is in the employees' own interest. This self-interest should be bolstered by directly giving the employees a share of the company's profits or indirectly rewarding their efforts in the employee assessments, which make ´commitment and dedication` part of the criteria for incentive bonuses.

Definition:
A suggestion for improvement is any useful and realizable idea that is designed to achieve a positive change of the current state; regardless of how far the idea has been thought through to its actual implementation.

For an idea to be considered a suggestion for improvement, it needs to

- provide an improvement over the current state,
- be cost-effective in its implementation,
- be innovative in its methods (in the respective area of application),
- not have been considered or implemented without the proposition by the employee.

The criterion of being cost-effective could be replaced by image gain for the company or improvement of workplace safety (or combinations thereof!).

Suggestions for improvement may refer to technical, organizational, commercial or social situations.

Suggestions for improvements should be differentiated from

- the obligations of the employees, as stipulated by standard employment contracts, to always strive to optimize one's own performance. Therefore, improvements in one`s own area of work are usually not rewarded;
- technical inventions, in the sense of the Employee Inventions Act, which differentiates
  - utility models (German: Gebrauchsmuster), entry into utility model registers , and
  - patents, entry into patent registers

  (complex technical requirements, longer protection period, intensive research).

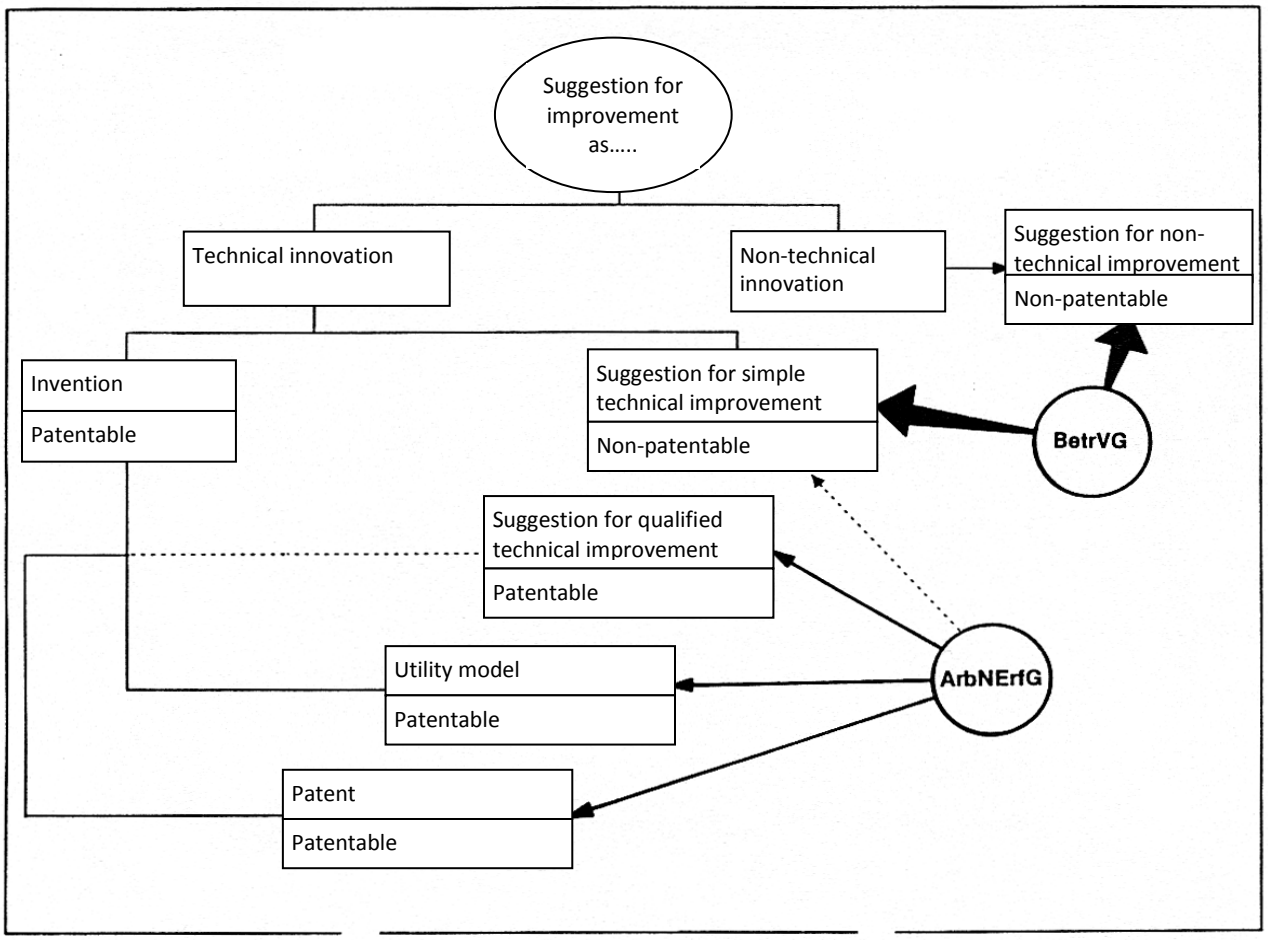


Figure 4.7: Types and delineations of patentable and non-patentable suggestions

Suggestion systems are an integrated part of the innovation-instrument-mix of a company:

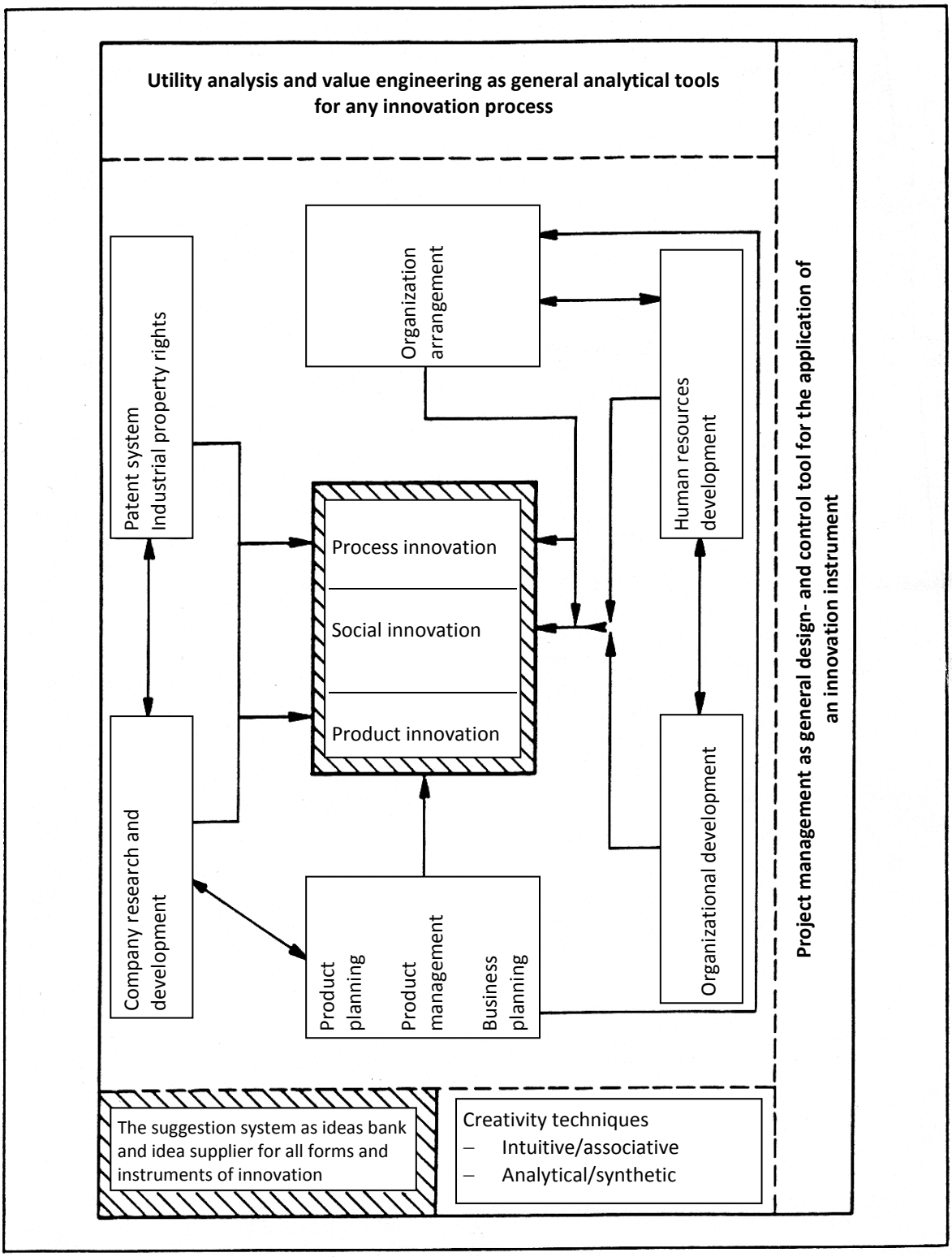


Figure 4.8: The innovation-instrument-mix (according to Thon)

4.4.2 The legal basis for suggestion systems

The Work Constitution Act (= Betriebsverfassungsgesetz) stipulates an obligatory right to co-determination by the workers' council for the fundamentals of a company's suggestion system (§87.1 Ziff. 12 BetrVG).

Furthermore, the Federal Labour Court (= Bundesarbeitsgericht) has granted workers' councils a limited right to initiative, which in business practice has further developed into an unlimited right.

A company's suggestion system is defined in the form of a company agreement.

Issues that are subject to co-determination are:

- structure and general organization of the suggestion system
- definitions, which help delineate a suggestion for improvement
- reward policy and evaluation criteria
- a suggestion-system-representative as institution (not as person!)
- arrangement of the classification process, as well as regulations for the proceedings within the suggestion-system-institutions.

Issues that are not necessarily subject to co-determination:

- the reward framework;
- decisions about the monetary factor per assessment point;
- decisions about the amount of individual premiums;
- granting of premiums for suggestions which were not implemented;
- appointment of the suggestion-system-representative;
- decisions about the overall use of suggestions for improvement under consideration of co-determination by the workers' council according to § 91 BetrVG

4.4.3 Regulatory issues of suggestion systems

a) Presenter of the suggestion for improvement

It makes sense to let as many employees as possible participate in a suggestion system (in the sense of eligibility for premiums). This, of course, includes all regular employees, such as tariff and non-tariff staff, temporary workers, interns, trainees and usually retirees.

Normally executive employees are excluded from the suggestion system, since engagement beyond the scope of their own section is already expected from them.

Temporary workers should also be included in the group of people eligible for premiums.

External personnel, such as delivery personnel, freight forwarders, and repair and maintenance personnel often recognize opportunities for improvement for the company. To exclude them would mean bypassing an important source for suggestions.

The inclusion of visitors in the suggestion system would be a good idea, but the author knows of no company which does this.

The paying of premiums to employees of other companies, which have come to the company expressly to provide suggestions for improvement, be it in the form of a customer advisory council or during a benchmarking-process, is controversial.

It is important to have a clear policy for how to treat suggestions by groups, in particular if they were expressly established for the purpose of discussing changes within the company and developing corresponding suggestions (learn-shops, circles of quality). Progressive companies have developed ´special regulations`.

b) The suggestion-system-representative

For each plant a representative responsible for the suggestion system is appointed. He is the contact person for employees. Furthermore, he is responsible for the registration and administrative supervision of the assessment- and evaluation-process.

Needless to say, the suggestion-system-representative is the driving motor of a suggestion system. Initiative, constant campaigning and providing new impulses are all expected of him. Furthermore, he should never betray the trust placed in him as ´honest broker` of the suggestions entrusted to him.

c) The assessor

Assessors can be experts from various fields. For larger companies they might be from the section affected by the suggestions or from neighboring departments.
Since the assessment of a suggestion not only involves the technical feasibility, but also organizational, safety-related, economic and management-related aspects, some companies install assessor teams or assessment committees. Their services are employed regularly or on a case-by-case basis. Perhaps a preliminary assessment is conducted in a meeting and only suggestions rated as promising are delegated to an expert for an individual assessment.

Smaller companies, in particular, are forced to rely on the help of external specialists.

d) The evaluation committee

An evaluation committee is composed of, preferably neutral, experts. Participation takes the form of additional voluntary duties, which might entail a significant amount of work (without being compensated correspondingly!).
The members see themselves as providing benevolent evaluation of the suggestions, under consideration of the company's economic interests.

e) Premium design

Each company will develop its own specific valuation method.
But they all will have valuation methods in common for suggestions with ascertainable benefits and for such which can not be expressed in a monetary equivalent.
Some valuation factors can be found again and again:

- originality refers to the degree of intellectual effort, the novelty of the procedure, tools, etc. ;
- feasibility refers to the potential technical-organizational-economic implementation of the suggestions;
- maturity refers to how far the suggestions have been developed towards (immediate) implementation.

In addition, there might be correction factors, which

- take into account the position of the proposer within the company's hierarchy (the higher the hierarchical level of the proposer, the lower the premium);
- the ´closeness` of the proposer to the organizational area or process, affected by the suggestion (the further away, the higher the premium)
- the degree of creativity and novelty of the suggestion, as well as
- other sensible factors.

The most important basis for reference is the net savings for the company, through implementation of the suggestion. These are the total savings (of e.g. 24 months) minus the costs of implementation (e.g. investments, costs of process adjustments). The employee is granted a certain percentage of these savings.

The amount of the premiums can also be based on a point-system. This approach is used in particular for suggestions with benefits, which can not be directly ascertained.

1. Position of the proposer:	**Points**
• unskilled worker; trainees	3
• skilled workers and employees	2
• managers	1
2. work field:	
• unrelated	6
• related	3
• own	1
3. usability:*	
• exceptional	31 to 100
• high	11 to 30
• medium	up to 10
• low	4
• pointing out of faults (NES,NAS)**	1
4. implementation readiness:	
• ready for implementation	2
• not yet ready for implementation	1
• needs further development	0.5

5. premium formula:

P = Po x W x (Ux10DM/point) x I

P	=	premium
Po	=	position of the proposer
W	=	work field
U	=	usability
I	=	implementation readiness

* Usability is the most important category. One point is equivalent to 10 DM. Usability is mostly based on the yearly material benefits. If the material benefits can not be ascertained or if the benefits are purely immaterial, the usability has to be estimated.

** NES = note of a potential error source
NAS = note of a potential accident source

Figure 4.9: Point-based valuation plan for suggestions with unascertainable benefits ((taken from the brochure “Mitarbeit-Mitdenken” (=Working and thinking in cooperation) published by the Bavarian State Ministry of Employment and Social Order (=Bayerische Staatsministerium für Arbeit und Sozialordnung)).

A third option is the awarding of premiums according to factor valuation. Two factors each are combined using a factor-square. This procedure is generally known to be quite complicated.

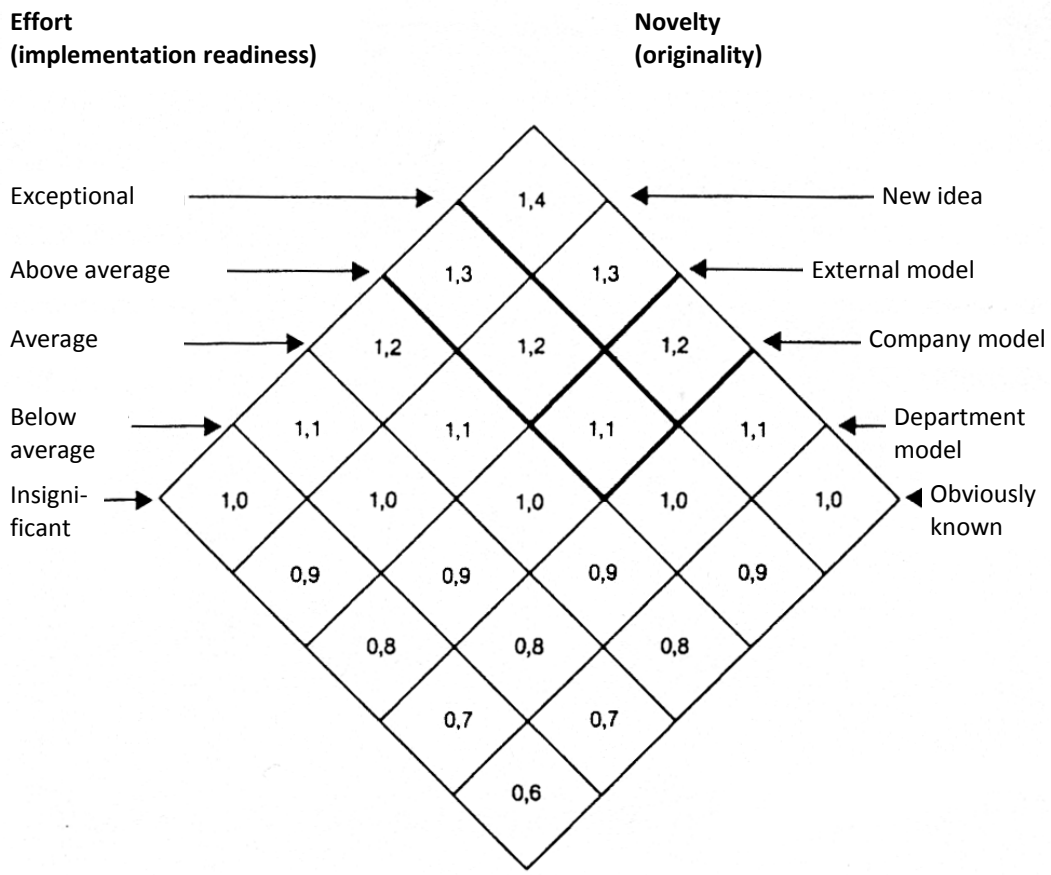


Figure 4.10: Factor valuation for ímplementation readiness`and ´novelty` (Spahl's factor square) benefits ((taken from the brochure “Mitarbeit-Mitdenken” (=Working and thinking in cooperation) published by the Bavarian State Ministry of Employment and Social Order (=Bayerische Staatsministerium für Arbeit und Sozialordnung)).

Recognition premiums reward the prudent and interested work-conduct of the proposer; they are granted for suggestions with low net values for the company or suggestions which were accepted, but not implemented. They are granted in the form of monetary rewards or appropriate gifts.

Preliminary premiums are granted, if the implementation of the suggestion can be expected to yield savings, but which can only be precisely ascertained after implementation and testing of the innovation. The final premium is calculated later and then granted.

Providers of multiple suggestions could receive an additional premium for every, say, 10 rewarded suggestions.

The amount of the premium is also dependent on whether the suggestion is only applicable at the proposer's location or at other plants as well.

Most companies only reward suggestions that have actually been implemented. Others reward suggestions even if the implementation does not seem reasonable, for whatever reasons (at least for now); in these cases the premium is of course significantly smaller!

4.4.4 The technical-organizational processing-procedure of suggestion systems

The suggestion is to be submitted in some suitable form (i.e. most often written) to the suggestion-system representative.
Many companies design blank forms to administratively optimize the processing-procedure.
It is common for the suggestion-system representative to help the proposer in preparing his suggestion; some companies expect the proposer's superiors to support him and even give a first opinion.
More conservative companies keep the proposer anonymous, until the final decision is made to prevent potential repercussions by colleagues and superiors.

The proposer receives a receipt.

The suggestion for improvement is then presented to one, or sometimes even multiple experts, either simultaneously or consecutively.
The reviewed suggestion is then presented to the valuation committee, which then, if applicable, determines the appropriate premium.

The employee is informed about the decision of the valuation committee.

The accounting department is then instructed to pay the determined premium. For premiums in the form of gifts a date for an ´award ceremony` is set.

In the case of dismissal of the suggestion, the proposer is given a letter with a detailed explanation of the reasons; some companies even arrange for a personal meeting with the proposer.

The employee has the right to appeal the decision within a set period of time!

If the process takes longer than usual, some companies provide the proposer with interim reports to inform him about the progress of the assessment- and evaluation-process.

4.4.5 Inhibitions regarding participation in a suggestion system

Despite efforts, in the form of constant campaigning and encouraging actions, many companies are not satisfied with the results of their suggestion system.

Obviously, there is some sort of barrier in the heads of employees that prevents (greater) success.

These can roughly categorized as capability-, motivational and risk-related barriers.

Table 4.2

Type of barrier	Manifestations	causes/indicators
capability-barriers	1. Thought-related problems ▪ lack of criticism ▪ lack of ideas ▪ lack of creativity 2. Formulation-related problems	▪ Insufficient training ▪ insufficient level of education ▪ deficiency-blindness due to routine ▪ non-constructive criticism
Motivational barriers	1. Indifference towards/disinterest in concerns of the company 2. reservations towards the company (or even towards the economic system) 3. adversity to change	▪ Low degree of identification with the company ▪ ideological differences ▪ laziness ▪ stubborness
Risk-related barriers	1. Fear of tangible disadvantages through suggestions for improvement 2. Fear of intangible disadvantages through the suggestion system	▪ Risk aversion ▪ pressure to conform ▪ general lack of commitment

The causes mentioned above also show ways to tackle potential barriers.

A suggestion system requires constant campaigning, often through the design of appropriate logos

Figure 4.11: examples of suggestion system logos

or formulation of convincing motivational slogans:

- ´Wer spinnt, gewinnt` (talking crazy makes you a winner) - Stahlwerke Röchling Burbach GmbH
- ´Gut gedacht, besser gemacht` (good thinking, better doing) - Deutsche BP AG
- ´Wir verwirklichen Ideen` (We turn ideas into reality) - MBB
- ´VV – Innovationen sichern unsere Zukunft` (VV – innovations secure our future) - Siemens AG
- ´Wir bei Audi – Wertvolle Ideen realisieren` (We at Audi – Turning valuable ideas into reality) - Audi AG

Suggestions systems have require constant critical reflection, on whether it is still up-to-date and, therefore, its effectiveness. Suggestion systems have been shown to require an overhaul from time to time.

On this, an excerpt from PLATTFORM, the company magazine of the Veba Oel AG (2/98):

´Good ideas pay off sooner and better`

´With the beginning of spring suggestion systems are starting to bloom again: In March a new company agreement containing attractive new regulations for employees was signed.

One of the highlights is the opportunity for spontaneously formed groups of employees to work on suggestions for improvement during work hours. In return, co-workers substituting for their colleagues get a share of the premium. A share of every premium awarded is paid into an ´employee pool`, which is distributed among the employees, according to operations, at the end of each year. ... Here, the valuation committee will swiftly and unbureaucratically assign suggestions to the categories A (immediate), B (possibly later) and C (not usable). In the long run most suggestions should be processed within 20 days ...`

Nowadays, rewards are usually no longer awarded for individual, often random, performances – sometimes even to the detriment of others, as presented above. Rather the systematic team-based problem solving should be aspired to and rewarded.

One possible approach is to get the supervisor of the department, in which the suggestion is to be implemented, involved in the process of change as soon as possible; ideally to have him actively participate in the detailed formulation or at least in the evaluation-procedure. This should prevent some of the blockades put up by managers.

Whether a suggestion system actually is effective and efficient or not, can be seen by consulting various key indicators. This requires reference values, as determined by the target numbers of previous years or of another company (or another part of the company).

- The participation ratio is the number of suggestions per hundred persons eligible for participation. It reflects the willingness to participate. So called repeat-proposers might cause a distortion of this key indicator, but this can be cleared up by additionally calculating the proposer-density.
- The proposer-density is the ratio of the number of proposers of suggestions to the total number of suggestions presented. This indicator shows whether there are repeat-proposers (if the proposer-density is low). A value of greater than 1 for this indicator shows a tendency for the more frequent presentation of team-based suggestions in the suggestion system.
- The acceptance ratio is the ratio of the number of accepted suggestions to the total number of suggestions presented; it reflects the quality of the suggestions, which were made.
- The implementation ratio is the ratio of the number of suggestions, which were actually implemented to the number of suggestions, which were merely accepted; this indicator also shows the contribution of the suggestion system to the streamlining and innovation efforts of the company, as well as the degree of opposition to change.
- The distribution ratio reflects the composition of the people, who made suggestions (occupation, department affiliation); it shows the degree of participation for the individual departments of a company.
- Type and amount of premiums: The total sum of all premiums, average and highest premiums reflect the quality of the suggestions, which were presented.

Group-based models attempt to selectively put together employees into teams, which then can more or less independently deal with opportunities for improvement.

The concept of Kaizen focuses on the mobilization of an organization, as a whole. The corporate culture should try to achieve a constant struggle by all employees for improvements within the company.

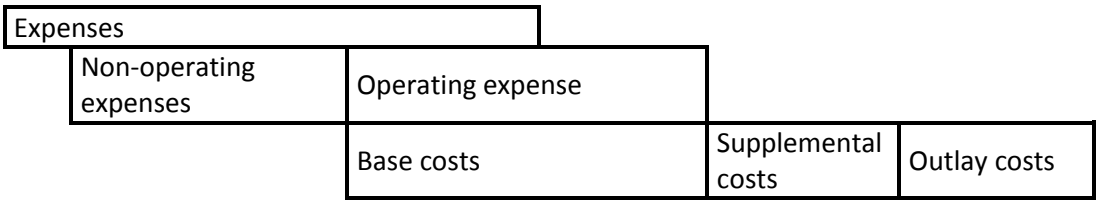
5. FUNDAMENTALS OF COST AND PERFORMANCE ANALYSIS

After you have gone through the next few pages, you will understand the terms income and expenses, base costs and additional costs, costs and performance, as well as operating data and non-operating results.

Important terms in cost and performance analysis are, as the name implies, costs and performance.

Performances are the finished and unfinished commodities, internal activity, and services that are performed, produced or provided by a business. A few examples are revenues generated by the sale of commodities, transport services performed by a shipper, excess inventory of products in warehouses and the production of tools and other business goods.

The following diagram applies to the **concept of expenses**:

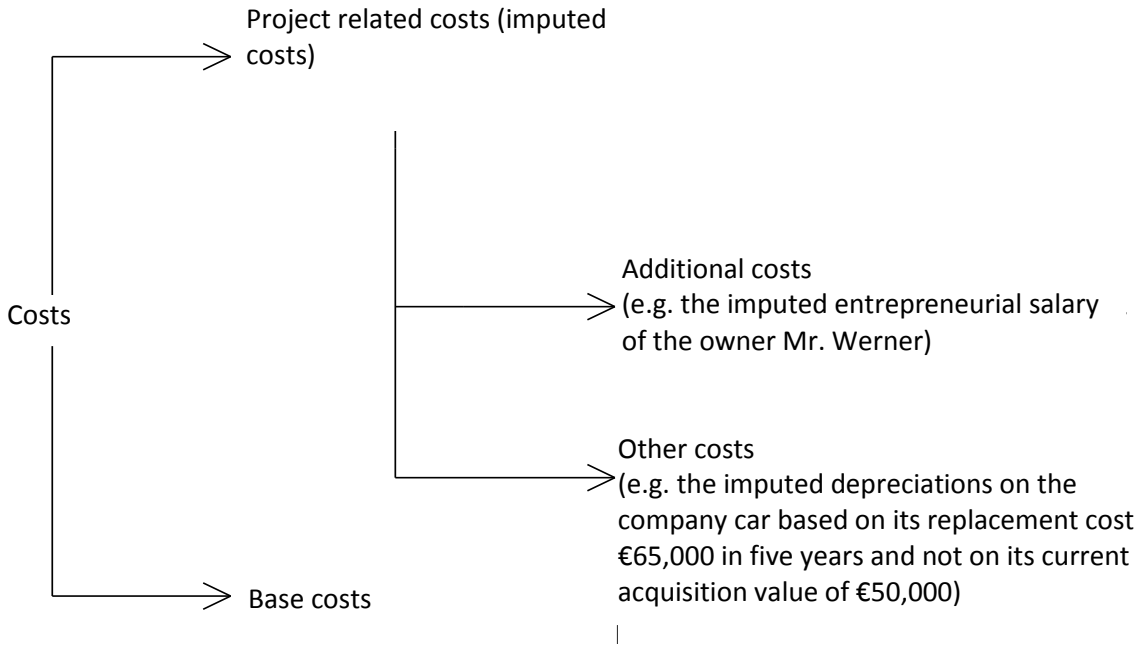


The **base costs** are equal to the operating expenses and correspond to the expenses listed in the business accounting records. These costs include wages and salaries, occupancy costs, energy use, insurance, administrative costs and the costs of the raw materials needed for production.

Neutral factors include non-operating expenses (expenses with no relation to operations), costs incurred outside of the current accounting period and unusual expenses (expenses that are unusually high or that occur irregularly). They also include income from holdings, income from the cancellation of accruals (unusual), losses from sales of bonds or shares (non-operating expense), payments of back taxes (from a different accounting period) or donations (non-operating expense).

Additional costs are costs that are not directly related to any particular job. Although they are not related to a specific project, they so impact expenditures and must be considered at some point. Such costs include the imputed entrepreneurial salary (the money the entrepreneur himself gets paid) which includes both the salary the entrepreneur draws as well as the interest he draws on the capital he invested in the company.

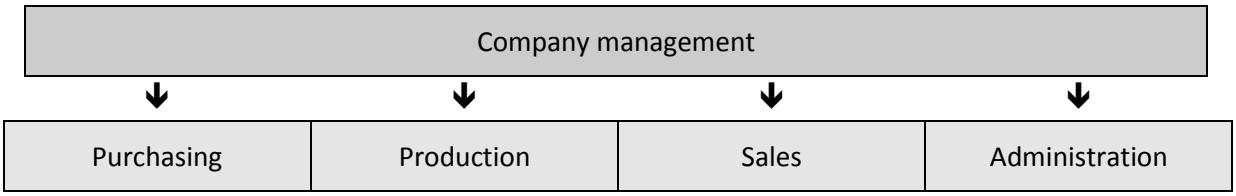
Other costs are costs which are not directly related to any actual payments such as imputed depreciation. These costs can also include certain imputed risks such as fire, explosion, theft, price drops, loss of investment and guaranty commitments.



5.1 Different cost elements and their outline options

Expenses can be sorted according to **production factors** which mean that the expenses can be sorted by their causes.
Possible production factors include materials (materials costs such as raw materials, nails, glue and packing material), work (labor costs such as wages, salaries, and insurance co-payments), operating materials (fuel, water), third-party services (service costs), capital (interest) and payments (taxes and fees).

Expenses can also be sorted according to their **function**. The expenses can be divided into procurement costs, manufacturing, marketing and administrative costs. Most companies are structured in this manner.



A further possibility is to sort expenses by the type of transaction they represent. It must be determined whether transactions can be categorized as itemized costs or general expenses.

Direct costs can be directly attributed to a specific order or job. These costs can include bills of materials, payrolls, invoices and so on.

Overhead refers to general costs incurred by a company and cannot be attributed to one specific project. Taxes, rent, salaries and imputed costs all fall under this category. Calculation keys are used to distribute the overhead costs among the various departments on a cost allocation sheet. The overhead expenses are then distributed among various cost objects by percentage.

The working relationship between the company and the workers is another factor in categorizing costs.

Fixed costs are unrelated to the sales situation and must always be paid, even when little to no work is actually being carried out (e.g. rent, salaries, and insurance). **Step costs** increase only after certain operating levels are exceeded (e.g. renting an additional production hall) and **variable costs** increase and decrease with the amount of work being carried out (e.g. production material, tools, and hourly wages).

In cost accounting, there are also differences between **base costs** and **additional costs**.

Base costs are associated with outlays for things like salaries, materials, services from other companies, etc.

Supplementary costs are not associated with any direct outlays. These are calculated as the difference between the costs imputed and the base costs that were actually incurred. For example, if our business had calculated an imputed write-off of €32,000 and the actual write-off was only €25,000, €7,000 in supplementary costs would be incurred.

5.2 Important type of costs in detail

Costs are incurred by using goods and services. This consumption must be monetized and this can take place in the form of incoming invoices, payrolls or stock prices.
In this section, we will be looking at manpower costs, material costs and imputed costs (depreciation, interest, risks, rent and the entrepreneurs' salary).

Manpower costs

Manpower costs can be divided into four main types.

- Wages
- Salaries
- other manpower costs
- Social-security payments

Payroll accounting registers the manpower costs from payrolls, time cards, etc. Sick leave, vacation pay and Christmas bonuses, overtime premiums, bonuses, commissions and the employer contribution to social insurance programs (unemployment, health and retirement insurance) must also be considered.

Material costs

Material costs are calculated for materials and supplies by multiplying the unit cost by the amount of units used.

Table 5.1

Production materials	Supplies	Operating supplies
e.g. Externally procured parts Raw materials Construction materials	e.g. Rivets, Paint, Electrodes, Screws	e.g. Heating oil, Coolant, Sandpaper, Lubricating oil, Gas
Used as main components in the manufactured products	Auxiliary components used in the manufactured products	Not used directly in the manufactured product but needed to enable production
Direct costs	Overhead costs	Overhead costs

Service costs

Service costs are incurred by using third-party services. Determining what kind of costs they represent is very simple because the information is on the invoice. Below are some examples of possible service costs:

- Rent
- Leases
- Lease payments
- Tax and legal consulting
- Freight and transport costs
- Travel expenses
- Allowances, entertainment expenses
- advertising costs

Imputed depreciation

Imputed depreciation attempts to include the wear and tear on machinery and property when calculating the sales price of a product. The maintenance of the value of assets is a priority. To calculate this number, estimate the amount of time that a machine will be used and then determine the percentage of value that the machine will lose due to this work. This percentage is based upon the replacement cost of the machine and its expected service life. After the value of a piece of machinery has completely depreciated, it retains the value of €1 on the balance sheet.

Let's use the example of a grinder. The cost of acquisition is €100,000 and the service life is estimated to be 5 years. This results in a yearly imputed and financial depreciation of €20,000. After 5 years it is determined that the actual service life is 8 years because the machine has been operated with care by experienced workers. The replacement cost has also risen by €18,000.

The imputed depreciation in the 6th, 7th and 8th year is now €6,000 (€18,000 divided by 3 years). On the balance sheet, the depreciation was completed after the 5th year.
If this situation had been clear from the beginning, it would have been possible to calculate an imputed depreciation of 1/8 of the replacement cost of €118,000 (€14,750 per year).

Imputed interest

Interest payments that must be paid on borrowed capital are booked in the administrative accounting. Every entrepreneur has also invested his own money in the business rather than borrowing everything from a bank. Interest and dividends earned from the bank or through investments in other companies are also to be recorded. It is easy to understand that the entrepreneur would want to have the money that he invested also be subject to interest. This is carried out in the cost and performance analysis. The ways in which the money was used is to be registered. Only the necessary capital that was purchased with the money is subject to interest. The business relevant capital must be registered before applying the current interest rate for long-term repayment.

Imputed risks

Insurance does not cover every risk undertaken by a business. There is the risk in starting a business in the first place. This is called the general entrepreneurial risk. Demand can drop or technology can progress so quickly that the company cannot keep up.

Risks can be divided into sales risks and production risks.

Sales risks	Individual risks
Marketing risks	System risks
Warranty risks	Inventory risks
	Additional costs / production risks
	Development risks

We now have to explain what is meant by the individual risks and what benchmarks must be set.

Risks with explanation ⇩	**Reference** ⇩
Marketing risks: Bad debts, losses due to changes in the value of currency	Revenue
Warranty risks: Warranty services, discounts, delivery of replacements	Revenue
System risks: Machine failure, shorter than expected service life of machines	Acquisition costs
Inventory risks: Loss of quality, obsolescence, loss or shrinkage	Production costs
Additional costs /production risks: Additional costs due to defects or reconditioning	Production costs
Development risks: Failure or setbacks in development	Production cost

Risk adjustment = $\frac{Loss\ incurred\ x\ 100}{Reference\ value}$

For example: A marketing venture risks €5,850 on revenue of €650,000.

Marketing risk adjustment = $\frac{€5{,}850\ x\ 100}{€650{,}000}$ = 0.9 %

Other reference values can be used depending on what risk you would like to calculate. Other variables include the debtor portfolio or the current inventory.

Imputed rent

A business that does not own any space of its own must rent warehouse, production halls and office space as needed and therefore must pay the corresponding monthly costs. If a stakeholder in a company or a sole proprietor provides space, the imputed rent according to local rates will be applied. This is only possible when no proportionate expenditures necessary for the proper maintenance of the building, imputed depreciation, building insurance or imputed interest have been considered.

Imputed rent falls in the category of additional costs.

Imputed entrepreneurial salary

The board members of publically traded companies and the presidents of private companies receive salaries that are entered as additional costs in the accounting books.

The owners or stakeholders of individual enterprises or business partnerships do not normally receive a salary as they receive a portion of the profits of the enterprise. The manpower costs are now calculated for the cost and performance analysis. The entrepreneur would receive a salary for working for another business so it would make sense that the entrepreneur receives a salary for the work performed in his own business. This salary should be based on the salaries of managerial employees in similar positions.

The imputed entrepreneurial salary is categorized as an additional cost that does not correspond to any specific job or order.

Mixed costs are expenses that have both **fixed** and **variable** components. When calculating expenses, these costs are separated into their fixed and variable components.

Examples:

Telephone expenses result from a time dependent flat rate along with a connection charge for each individual call.

Additional examples of mixed costs are: Costs for supplies, maintenance costs, energy costs, etc.

The following table presents an overview of which types of expenses can be divided into multiple types of expenses:

Table 5.2

Cost category	Cost categories	Explanation of terminology	Examples
Category of the production factors used	Personnel costs	Cost of work	Wages, salaries, social-security payments
	Material costs	Cost for the materials used	Raw, operational, auxiliary materials
	Service costs	Cost for services provided by other companies	Energy, transport, insurance
Operational functions	Procurement costs	Cost for the procurement of goods used for production	Staff, transport
	Manufacturing costs	Costs incurred from manufacturing	Worker wages, materials used for manufacture
	Marketing costs	Cost of sales activities	Sales force, advertising, market research
	Administrative costs	Cost of management, organization, accounting	Personnel costs, property costs, costs for workspace
Expense accounting category	Basic costs	Costs that are associated with specific jobs or projects	Wages, salaries, utilities, supplies, materials,
	Additional costs	Costs that are not associated with any individual project	imputed costs which go beyond the base costs

6. COST TYPE ACCOUNTING; COST CENTER ACCOUNTING, TIME UNIT ACCOUNTING AND COST UNIT ACCOUNTING

6.1 Operating statement and financial statement

When calculating revenues at the end of the business year, all expenses and earnings are subtracted from each other. The resulting number represents either the profit or the loss. It can be the case that expenses or income that are derived from external factors, other accounting periods or special circumstances are included in the result although they have nothing to do with actual operation of the company. This can lead to a false impression as to the health of the company operations. For example, income derived from rentals or financial investments can increase the level of profits but have nothing to do with core business of the company. Therefore, operating results, non-operating results and business performance must be differentiated.

Overall result = non-operating result + operating result

Let's look at the financial statement of Company X. First we will only see the total results for the year. Next, the earnings and expenses that were caused by external factors, other accounting periods and special circumstances are added to the non-operating results.

The overall result contains the following numbers:

Table 6.1

Account name	expenditures in €	revenues in €
Sales revenues		895,000
Revenue from investments		30,000
Revenue from release of provisions		5,000
Expenditures for supplies, raw materials and utilities	670,000	
Wages and salaries	150,000	
Depreciation of assets	30,000	
Losses on sale of securities	55,000	
Business tax	7,000	
Charitable donations	3,000	
Other expenditures	25,000	
Subtotal	940,000	930,000
Loss		10,000
Total	940,000	940,000

The expenditures exceed revenues by €10,000. Therefore this overall result shows a loss.

In the next step, we will split the results into operating and non-operating results. All of the items that do not have anything to do with day to day operations are put in the column for non-operating results. In this case, the revenue from investments (external), from the release of provisions (unusual) and the losses from the sale of securities (external) and from charitable donations (external) are considered to be non-operating expenses.

Table 6.2

Account name	Overall result Calculation of profits and losses		Only non-operating results		Operating results	
	Expenditures	Revenues	Expenditures	Revenue	Costs	Benefits
Sales revenues		895,000				895,000
Revenue from investments		30,000		30,000		
Revenue from release of provisions		5,000		5,000		
Expenditures for supplies, raw materials and utilities	670,000				670,000	
Wages and salaries	150,000				150,000	
Depreciation of assets	30,000				30,000	
Losses on sale of securities	55,000		55,000			
Business tax	7,000				7,000	
Charitable donations	3,000		3,000			
Other expenditures	25,000				25,000	
Subtotal	940,000	930,000	58,000	35,000	882,000	895,000
Loss		–10,000		–23,000	+13,000	
Total	940,000	940,000	58,000	58,000	895,000	895,000

You can see that the operating result shows a profit of €13,000 and that the loss is due to the non-operating results. That means that the operational side of the business is profitable and there is no need to fear for its viability. The business should consider reducing its outside investments as well as its charitable donations.

Short summary

- Expenses include all the outlays a company makes for goods, services and taxes in an accounting period.
- Operational expenses are determined in the operating results and include all income and expenses directly related to the day to day business of the company.
- Costs are the value-related expenses related to the use of goods and services, as well as expenses incurred in the production and manufacture of goods and services.
- Non-operating results have nothing to do with the day to day operations of the company and are not included in the cost and performance accounting.

Revenues = the total amount of money that comes into the company within an accounting period.

Revenues resulting from external or unusual circumstances and revenues that not from the relevant accounting period are considered non-operating results and are not included in the cost and performance accounting.

Operating revenue is the result of all the operational income and expenses.

6.2 Cost-type accounting

Cost-type accounting is the first step in cost accounting. It is the foundation for the following cost and performance accounting.

The following tasks must be carried out when performing a cost-accounting analysis.

- **Registering all costs incurred by the business**
- **Determination of the corresponding cost classifications.**
- **Cost assessment**
- **Separating the costs into fixed and variable costs**
- **Dividing the costs into direct costs, overhead and special direct costs**

When performing cost-accounting, three principles are very important:

A detailed budget plan and clear definitions of the type of direct costs should make the orderly registration and classification of the costs possible.

A **foundation of the integrity of cost-type accounting** is that all of the costs that the company incurred be recorded and that the dividing line between direct costs and non-operating costs is clear so that the non-operating expenses are not included in the calculation.

The costs recorded must be from the corresponding business year or other defined time period. This means that, in addition to cost classification, the dates of the incurred costs are also very important.

6.3 Cost center accounting

Cost center accounting lets you classify costs according to where they were incurred within the organization. The goal of cost center accounting is to make it easier to monitor business operations by doing the following:

- Continuously monitor cost trends within the company.
- Create areas of responsibility in order to increase the sense of responsibility within the cost centers.
- Generation of accounting documentation.

Expense distribution sheets carry out these tasks. The expense distribution sheet was developed in the 1920's and has been continuously expanded and refined in the years since.

6.3.1 Designing an expense distribution sheet

When carrying out cost center accounting, expense distribution sheets are a big help and should be created once a month. Expense distribution sheets are designed with the types of cost along the vertical axis and the cost centers along the vertical axis. The distribution of overhead costs into their individual cost centers can usually be carried out by looking at the invoices themselves. Payrolls, pick slips for utilities and supplies, etc. do not only have the information regarding the amount of money in question, but also information regarding the cost center that was involved.

There are some overhead costs that are a little more difficult to classify and assign. These costs must be indirectly sorted using defined calculations (keys). This is how expenses for rent, cleaning and heating are divided into surface areas. Payroll expenses are divided according to the number of employees and property insurance premiums are classified according to the associated costs. Developing these classification systems is the most difficult part of cost center accounting.

6.3.2 How cost center accounting works

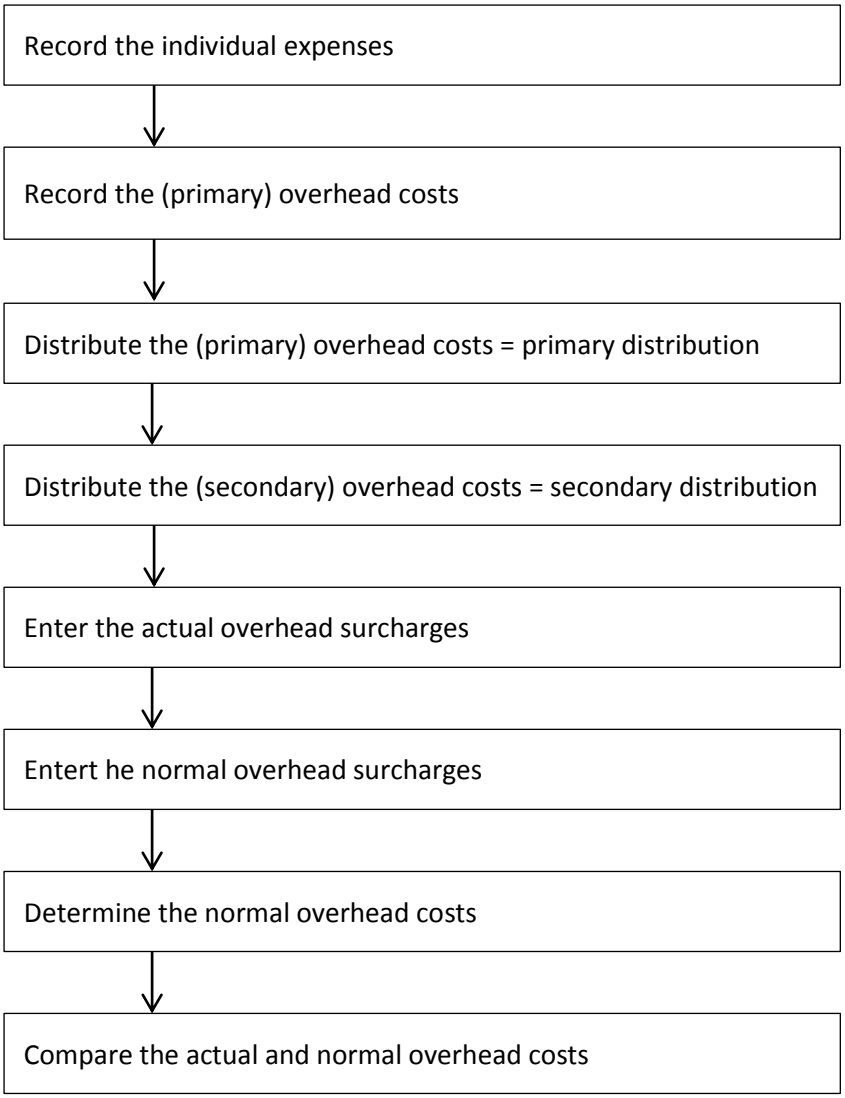
The overhead costs that have been classified according to their cost type (primary overhead costs) are then then sorted according to their cost center. Primary overhead costs are costs incurred from goods and services provided from outside sources (materials, salaries, telephone).

Costs that are incurred from indirect cost centers (secondary overhead costs) are distributed among the main cost centers within the framework of the company. These are called secondary costs because they are simply a redistribution of the primary overhead costs of the indirect cost centers to other cost centers.

Cost rates are determined for passing on the overhead costs to the cost bearers.

By comparing the anticipated costs with the actual costs, surpluses and shortfalls are determined so that an efficiency check can be carried out.

A diagram for creating an expense distribution sheet is below:



6.3.3 Designing a simple expense evaluation sheet

A basic design for a simple expense distribution sheet for an industrial business with four main cost centers would look like this:

Table 6.3

Cost center / Type of overhead cost	amount (€)	Distribution method	1 (€)	2 (€)	3 (€)	4 (€)
Overhead labor costs	1,000	direct	200	500	150	150
Energy costs	2,000	direct	500	1,200	100	200
...						
...						
Imputed depreciation	500	key	100	300	50	50
Sum of overhead costs by type						

The overhead costs are sometimes distributed rather arbitrarily among the cost centers because an accurate classification of the costs would be too difficult or time consuming. This can be the case with water usage because it is completely arbitrary to divide the water usage among the water connections in the business. The only way to accurately classify the water usage among the cost centers would be to have a water meter at every water fixture.

Example:

The following costs were incurred in the space on one month:

Production material	€360,000
Indirect materials	€20,000
Production wages	€70,000
Indirect labor costs	€35,000
Salaries	€50,000
Office space	€30,000
Energy costs	€40,600
Maintenance	€7,950
Imputed depreciation	€29,900
Imputed interest	€25,000

We have four main cost centers:

- Materials
- Production
- Administration
- Marketing

The following basis for distributing the overhead costs among the cost centers would be used:

Table 6.4

Overhead costs	Basis of distribution	Materials	Production	Admin-istration	Marketing
Overhead costs for material	ratios	2	7	1	–
Indirect labor costs					
Salaries	ratios	1	10	2	1
Office space	ratios	2	6	5	3
Energy costs	area	260 m²	1,040 m²	120 m²	80 m²
Maintenance	vol. of space	350 m³	5,000 m³	250 m³	200 m³
Imputed depreciation	ratios	3	9	1	2
Imputed interest	ratios	2	14	4	3
	ratios	2.5	8	3	1.5

Using this method of distribution, the expense evaluation sheet would look like this:

Table 6.5

Overhead costs	Amount	Material	Production	Administration	Marketing
Overhead costs for material	20,000	4,000	14,000	2,000	–
Indirect labor costs	35,000	2,500	25,000	5,000	2,500
Salaries	50,000	6,250	18,750	15,625	9,375
Office space	30,000	5,200	20,800	2,400	1,600
Energy costs	40,600	2,450	35,000	1,750	1,400
Maintenance	7,950	1,590	4,770	530	1,060
Imputed depreciation	29,900	2,600	18,200	5,200	3,900
Imputed interest	25,500	4,250	13,600	5,100	2,550
Sum of the primary overhead costs	238,950	28,840	150,120	37,605	22,385

After determining the overhead costs for the individual cost centers, the overhead rates can then be determined. These rates are needed for calculating the operating performance.

The direct costs (production wages) come out to €70,000. The overhead costs of the production cost center come out to €150,120.

The overhead rate is then: $\frac{150{,}120\ x\ 100}{€70{,}000}$ = 214.46%

This process is repeated for the other cost centers to determine the overhead rates. The direct costs and the sum of the overhead costs are the two numbers that are needed to perform this calculation.

6.3.4 Expanded expense distribution sheets

Direct costs are not calculated in cost center accounting

For this reason, direct costs do not have to be entered in the expense distribution sheet even though this is often done anyway.

The first step in creating our expanded expense distribution sheet is seen in the **first row**:

Table 6.6

Cost centers / Cost type	Numbers provided by accounting	General center		Material center	Production centers					Admin-istration center	Sales center
					Aux center	Aux center	Aux center	Aux center	Total A+B		
		1	2		1	2	A	B			
Production material	20,000			20,000							
Production salaries	12,000						4,000	8,000	12,000		

Recording primary overhead costs

Primary overhead costs are overhead costs that appear in cost centers as individual cost types. These numbers are taken from cost accounting.

This results in the second row of our example expense distribution sheet looking as follows:

Table 6.7

Cost centers / Cost type	Numbers provided by accounting	General center		Material center	Production centers					Admin-istration center	Sales center
					Aux center	Aux center	Aux center	Aux center	Total A+B		
		1	2		1	2	A	B			
Production material	20,000			20,000							
Production salaries	12,000						4,000	8,000	12,000		
Operating supplies	5,000										
Energy	1,000										
Indirect labor	10,000										
Wages	6,000										
Depreciation	2,400										
Other	4,000										

6.3.5 Distribution of the primary overhead costs

The third step in creating the expense distribution sheet is to distribute the primary overhead costs among all of the associated **main** and **indirect cost centers** and then to determine the sum of costs in each cost center.

The following must be differentiated:

Cost center direct costs that can be directly attributed to individual cost centers because they have individual pick slips or invoices associated with them such as electricity running through individual meters or wages for employees within a cost center.

Cost center overhead costs that cannot be directly attributed to a single cost centers but can be instead determined using defined **distribution keys**.

An example of the distribution of cost center overhead costs: The distribution of the cost type “energy”, which in our example has a value of 1,000, is carried out as follows:

1. Distribution key: 3 : 6 : 8 : 5 : 4 : 6 : 8 : 5 : 5
2. Creation of the key sums: 3 + 6 + 8 + 5 + 4 + 6 + 8 + 5 + 5 = 50
3. Determination of the key unit: 1,000 : 50 = 20
4. Determination of the cost per cost center: 3 · 20 · = 60; 6 · 20 = 120; 8 · 20 = 120

The results of this process can be seen in our example expense distribution sheet:

Table 6.8

Costs centers / Cost type	Numbers provided by accounting	General center		Material center	Production center					Admin-istration center	Sales center
		1	2		Aux center 1	Aux center 2	Aux center A	Aux center B	Total A+B		
Production material	20,000			20,000							
Production salaries	12,000						4,000	8,000	12,000		
Operating supplies	5,000	100	160	300	600	640	1,020	1,260	2,280	480	440
Energy	**1,000**	**60**	**120**	**160**	**100**	**80**	**120**	**160**	**280**	**100**	**100**
Indirect labor	10,000	200	300	600	1,100	1,200	1,800	3,400	5,200	600	800
Wages	6,000	120	140	340	400	560	1,300	1,420	2,720	800	820
Depreciation	2,400	60	80	160	280	320	560	580	1,140	180	180
Other	4,000	120	90	230	400	320	780	570	1,350	600	890
Sum	**28,400**	**660**	**890**	**1,790**	**2,880**	**3,120**	**5,580**	**7,390**	**12,970**	**2,760**	**3,330**

6.3.6 Distribution of secondary overhead costs

As the costs of the expense distribution sheet will be entered in the **cost accounting**, but only the main cost centers can pass on their costs, the following cost centers must be broken down further so that their costs can be attributed to **main cost centers**:

- **General cost centers**
- **Auxiliary cost centers**

This process is called the **distribution of secondary overhead costs**.

Secondary overhead costs are distributed using the so-called **step method** that enables you to distribute internal operations from the secondary cost centers to the **main cost centers** in stages.

The distribution of secondary overhead costs using the **step method** is carried out using an **apportionment formula** and follows the same procedure as was used in distributing the main overhead costs.

The following **apportionment formula** applies for our example expense distribution sheet:

- General cost center 1: 1 : 2 : 2 : 1 : 1 : 2 : 1
- General cost center 2: 1 : 0 : 0 : 1 : 1 : 1 : 1
- Auxiliary cost center 1: 1 : 2
- Auxiliary cost center 2: 1 : 1

After allocating the general cost centers and auxiliary cost centers, the expense distribution now look like this:

Table 6.9

costs centers / type of costs	Numbers provided by accounting	General center		Material center	Production center					Admin-istration center	Sales center
		1	2		Aux center 1	Aux center 2	Aux center A	Aux center B	Total A+B		
Production material	20,000			20,000							
Production salaries	12,000						4,000	8,000	12,000		
Operating supplies	5,000	100	160	300	600	640	1,020	1,260	2,280	480	440
Energy	**1,000**	**60**	**120**	**160**	**100**	**80**	**120**	**160**	**280**	**100**	**100**
Indirect labor	10,000	200	300	600	1,100	1,200	1,800	3,400	5,200	600	800
Wages	6,000	120	140	340	400	560	1,300	1,420	2,720	800	820
Depreciation	2,400	60	80	160	280	320	560	580	1,140	180	180
Other	4,000	120	90	230	400	320	780	570	1,350	600	890
Total	**28,400**	**660**	**890**	**1,790**	**2,880**	**3,120**	**5,580**	**7,390**	**12,970**	**2,760**	**3,330**
Allocation Gen. Cost center 1				66	132	132	66	66	132	132	66
Allocation Gen. Cost center 2				178	0	0	178	178	356	178	178
Total			①	**2,034**	**3,012**	**3,252**	**5,824**	**7,634**	**13,458**	**3,070**	**3,574**
Allocation indirect cost center 1							1,004	2,008	3,012		
Allocation indirect cost center 2							1,626	1,626	3,252		
Total							**8,454**	**11,268**	**19,722**	**3,070**	**3,574**
							②	③	④	⑤	⑥

6.3.7 Determination of actual overhead rates

The **actual overhead rate** is determined by dividing the **overhead costs of the individual main cost centers** by the **direct costs of the corresponding main cost centers**.

This results in the following formulas for the actual overhead rates:

$$\text{Actual material overhead rate} = \frac{material\ general\ overhead\ x\ 100}{production\ material}$$

$$\text{Actual production overhead rate} = \frac{production\ general\ overhead\ x\ 100}{production\ wages}$$

$$\text{Actual administration overhead rate} = \frac{administrative\ general\ overhead\ \ x\ 100}{cost\ of\ goods\ sold}$$

$$\text{Actual marketing overhead rate} = \frac{marketing\ general\ overhead\ x\ 100}{cost\ of\ goods\ sold}$$

The following applies to the cost of goods sold:

	Production material
+	Material overhead costs
+	Production wages
+	Production overhead costs
=	Cost of production
+	Minimum stock
−	Surplus inventory
=	Cost of goods sold

This results in the following actual overhead rates in our example expense distribution sheet:

1: 2,034 · 100 : 20,000 = 10.17%
2: 8,454 · 100 : 4,000 = 211.35%
3: 11,268 · 100 : 8,000 = 140.85%
4: 19,722 · 100 : 12,000 = 164.35%
5: 3,070 · 100 : (20,000 + 2,034 + 12,000 + 19722) = 5.71%
6: 3,574 · 100 : (20,000 + 2,034 + 12,000 + 19722) = 6.65%

Table 6.10

costs centers / type of costs	Numbers provided by accounting	General center		Material center	Production center					Admin-istration center	Sales center
					Aux center	Aux center	Aux center	Main station	total A+B		
		1	2		1	2	A	B			
Normal overhead rates in %				10.17			211.35	140.85	164.35	5.71	6.65

6.3.8 Adding the normal overhead rates

In order to use cost center accounting for the purpose of oversight, one should refer to past experience and information which are used to generate the **applied overhead rate**.

This results in the following row in our example expense distribution sheet.

Table 6.11

costs unit / type of costs	Numbers provided by accounting	General center		Material center	Production area					Administ ration center	Sales center
					Support center	Support center	Main center	Main center	total A+B		
		1	2		1	2	A	B			
total				**2,034**			**8,454**	**11,268**	**19,722**	**3,070**	**3,574**
Actual overhead rates in %				10.17			211.35	140.85	164.35	5.71	6.65
Applied overhead rates in %				9.70			210.10	143.20		4.70	6.65

6.3.9 Determination of applied overhead costs

The comparison between past results and the actual cost trends requires that deviation be measured in units of money which means that the applied overhead costs must be calculated using the actual overhead costs as a basis.

The following formulas apply:

Applied material overhead costs = actual production material x normal rate
Applied production overhead costs = actual production wages x normal rate
Applied administrative overhead costs = actual production costs x normal rate
Applied marketing overhead costs = actual production costs x normal rate

The standard production costs are calculated as follows:

Actual production material
\+ Standard material overhead costs
\+ **Actual production wages**
\+ Standard production overhead costs
= Standard cost of production
\+ Minimum stock
− Surplus inventory
= Standard cost of goods sold

Our example expense distribution sheet now looks like this:

Table 6.12

costs unit / type of costs	Numbers provided by accounting	General center 1	General center 2	Material center	Production area: Support center 1	Production area: Support center 2	Production area: Main center A	Production area: Main center B	Production area: total A+B	Administration center	Sales center
Applied overhead costs				1,940			8,404	11,456	19,860	2,527	3,575

Expense distribution sheet: Applied overhead costs

6.3.10 Comparison of the actual and applied overhead costs

A comparison of the **actual** and **applied overhead costs** will show if too many costs have been incurred, which means that the overhead costs were **under applied**, or the opposite which means they were **over applied**.

This comparison is the last step in creating an expense distribution sheet.

The following applies to shortfalls and overfunding:

Over/under applied = applied overhead costs – actual overhead costs

If the applied overhead costs exceed the actual overhead costs, this is referred to as over-applied overhead or:

Applied overhead > actual overhead = over-applied overhead

Applied overhead < actual overhead = under-applied overhead

The final completed expense distribution sheet can be seen below:

Table 6.13

Cost unit / Type of costs	Numbers provided by accounting	General center		Material center	Production area					Administration center	Sales center
		1	2		Support center 1	Support center 2	Main center A	Main center B	total A+B		
Production material	20,000			20,000							
Production salaries	12,000						4,000	8,000	12,000		
Operating supplies	5,000	100	160	300	600	640	1,020	1,260	2,280	480	440
Energy	**1,000**	**60**	**120**	**160**	**100**	**80**	**120**	**160**	**280**	**100**	**100**
Indirect labor	10,000	200	300	600	1,100	1,200	1,800	3,400	5,200	600	800
Wages	6,000	120	140	340	400	560	1,300	1,420	2,720	800	820
Depreciation	2,400	60	80	160	280	320	560	580	1,140	180	180
Other	4,000	120	90	230	400	320	780	570	1,350	600	890
Total	**28,400**	**660**	**890**	**1,790**	**2,880**	**3,120**	**5,580**	**7,390**	**12,970**	**2,760**	**3,330**
Allocation Gen. Cost center 1				66	132	132	66	66	132	132	66
Allocation Gen. Cost center 2				178	0	0	178	178	356	178	178
Total				**2,034**	**3,012**	**3,252**	**5,824**	**7,634**	**13,458**	**3,070**	**3,574**
Allocation indirect cost center 1							1,004	2,008	3,012		
Allocation indirect cost center 2							1,626	1,626	3,252		
Total				**2,034**			**8,454**	**11,268**	**19,722**	**3,070**	**3,574**
Actual overhead rates in %				10.17			211.35	140.85	164.35	5.71	6.65
Applied overhead rates in %				9.70			210.10	143.20		4.70	6.65
Applied overhead				1,940			8,404	11,456	19,860	2,528.6	3,577.7
over/under- applied overhead				-94			-50	188	138	-541.40	3.70

6.4 Cost object accounting

Cost object accounting expands upon cost type accounting and cost center accounting. It serves to manage the pricing and product mix policy as well as inventory management.
It raises the question as to why certain costs are incurred.

Cost object accounting should provide the information necessary to effectively manage pricing and product mixing. If the market has already set certain prices, the business must determine which articles can be sold for a profit or at least at a minimal loss.

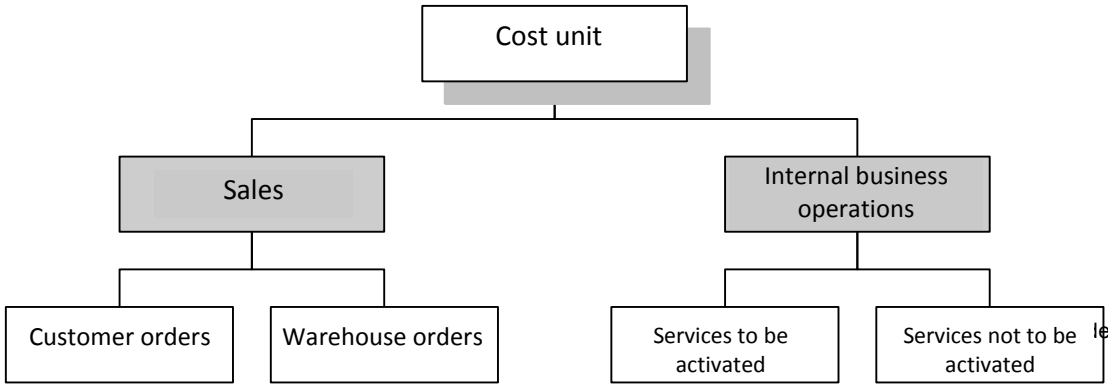
Cost object accounting is the third step in cost accounting. The first step was carried out when expenses were recorded during cost type accounting. In the second step, cost center accounting, the cost units from the cost centers were distributed to determine the overhead rates that will be used in cost object accounting. The individual costs of the cost units form the foundation for determining rates for calculating the overhead for cost-bearing units. The following representation will focus on the **calculation of the cost units**.

Cost object accounting is based on three principles:

- The **principle of cost causation** says that costs are to be **exactly** distributed amount the cost units.
- The **principle of averages** is a watered-down version of the principle of cost causation whose goal is to distribute the costs as **accurately as possible**.
- The **principle of cost unit capacity** is used to distribute the costs among the cost-bearing units according to their individual **load capacities**.

Cost units are products or services that a company produced which incurred costs in their production.

Cost units are divided into the following categories:



Sales refers to orders placed by individual customers and the market as a whole. **Customer orders** are orders placed directly for goods or services. This type of order is more common in individual and small series production. **Warehouse orders** are orders that have been placed by the anonymous market. Large series and mass production lines are usually indicative of this kind of order. Warehouse orders ensure that a company is always ready to provide the market with its goods.

With internal business operations, the business itself is the customer for the products that are to be produced. If the produced products can be used over multiple accounting periods, then they go on the company's balance sheet and can be activated at any time which is why they are referred to as **services to be activated**. If the products are manufactured and used within the same accounting period, then they are referred to as **services not to be activated**.

Cost unit accounting can be carried out in two ways:

Cost unit accounting is used to distribute the company's total expenses among the products produced within a given accounting period. The total cost incurred in producing each individual type of product within a given accounting period is calculated.

Per unit cost accounting determines the cost of each produced cost unit.

6.4.1 Cost unit accounting structure

Preliminary and final costing

Preliminary and final costing is carried out for every project. Preliminary costing is carried out before the project begins. The costs are estimated for the purpose of tendering an offer. The direct costs can be calculated relatively accurately and the overhead costs are calculated using average values. This stage will provide you with enough information to decide whether or not to take on a job.

The final costing contains the actual costs and you will be able to compare them with the preliminary numbers. These numbers can be analyzed to ensure or improve the economic viability of your business operations.

A detailed example can be found in chapter 7.

The differences between the preliminary and final costing can be easily summarized. The preliminary pricing works with target costs that are determined from past experience and is used to prepare a preliminary offer price. The final pricing includes the actual costs incurred in the production of the goods and is used for determining the final selling price.

Assessment of company departments

Cost unit accounting is very useful in assessing the performance of various cost centers within a company. The products (in the form of cost units) and their associated costs and revenues can be easily categorized. Success is measured by the difference between the costs and revenues. Business and product viability can be easily monitored in this fashion. If losses are incurred within a cost center, the cause must be located and dealt with. If the problem cannot be solved, the costs center should be dissolved or the company should expand into a different profitable field.

Evaluating inventory

Cost unit accounting is also very helpful in evaluating inventory at the end of the business year. Inventory includes both finished and unfinished products. It can be difficult to evaluate the inventory if the means of production are highly varied because the costs must be distributed very accurately in order to assess the inventory effectively.

6.4.2 Cost unit time accounting

Cost unit time accounting distributes the costs among the cost units using the supplemental overhead costs from the expense distribution sheet. The total individual cost of every cost unit (orders, products) will be determined.

The procedure for making these calculations has already been discussed. The calculation for an inventory change is below:

	Production material	
+	Material overhead costs	
	Material costs	Material costs
	Production wages	
+	Production overhead costs	
	Production costs	Production costs
=	Manufacturing costs of production	Manufacturing costs of production
+	Inventory reduction	
–	Inventory increase	
=	Cost of sales	Cost of sales
+	Administrative overhead costs	
+	Marketing overhead costs	
=	Prime costs of job	Prime costs
	Revenue	
–	Prime costs	
=	Operating result	

We will now take another look at company ABC. We will determine the operating results of the telescope and dome departments.

		Telescopes	Domes
	Production material	20,000	50,000
+	Material overhead costs 15 %	3,000	7,500
	Material costs	23,000	57,500
	Production wages	28,000	90,000
+	Production overhead costs 180 %	50,400	162,000
	Production costs	78,400	252,000
=	Manufacturing costs of production	101,400	309,500
+	Inventory reduction	5,000	–
–	Inventory increase	–	10,000
=	Cost of sales	106,400	299,500
+	Administrative overhead costs 8 %	8,512	23,960
+	Marketing overhead costs 3 %	3,192	8,985
=	Prime costs of job	118,104	332 445
	Revenue	131,904	375,945
–	Prime costs	118,104	332,445
=	Operating result	+13,800	+43,500

Goals of cost unit time accounting

It determines the manufacturing costs which serve as the foundation for inventory assessment.
It determines the prime costs and monitors viability (ratio of revenues to costs).
It calculates the operating results based on the individual products and within each individual department in the company.

6.4.3 Per unit cost accounting

With per unit cost accounting, both the preliminary and final pricing of jobs is carried out. Let's look at an example of preliminary pricing:

Material consumption:
Plastic €3,500, wood €1,200, glass €1,700

Use of the manufacturing plants:
Grinding shop €800, turning shop €300

Overhead rates for overhead costs:
Material point 20%, grinding shop 18%, turning shop 120%, administration 7%,
Sales 4%

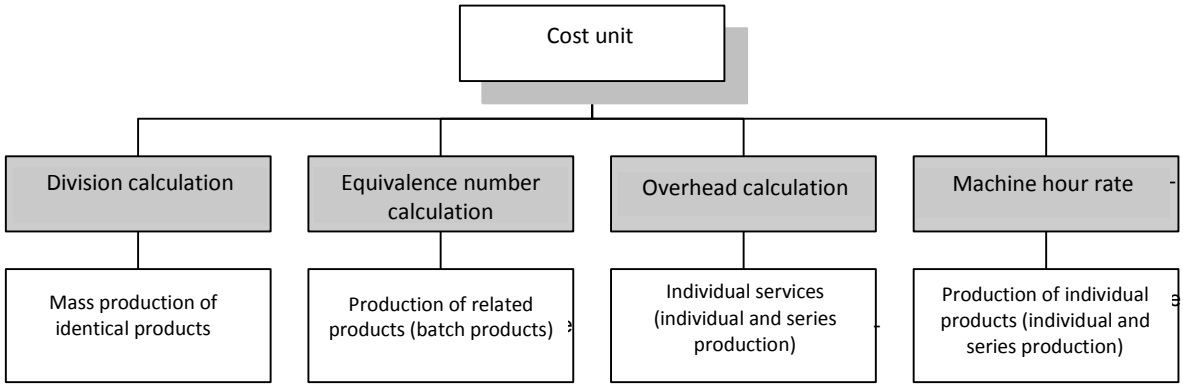
		€	€
	Production material		
	Plastic	3,500	
	Wood	1,200	
	Glass	1,700	6,400.00
+	Material overhead costs 20 %		1,280.00
=	Material costs		7,680.00
	Production wages		
	Grinding shop	800	
	Turning shop	300	1,100.00
+	Production overhead costs for grinding shop 18%		144.00
+	Production overhead costs for turning shop 120%		360.00
=	Production costs		1,604.00
=	Manufacturing costs		9,284.00
+	Administrative overhead costs 7%		649.88
+	Administrative overhead costs 4%		371.36
=	Prime costs of job		10,305.24

A profit of 6% is anticipated which results in a sale price of €10,923.55.

Goals of per unit cost accounting

Calculation of offer price (preliminary pricing)
Checking the costs after production (final pricing)
Deciding whether to take on jobs at the offered market prices (break-even analysis)

The following diagram gives as overview of the various procedures in per unit cost accounting:



Work through the following theoretical fundamentals.

Division calculation

The three relevant forms of division calculations are single-stage division calculation, multiple-stage division calculation and division calculation with equivalence numbers.

Single-stage division calculation

This type of calculation is used in companies that have only one production center where a differentiation of the costs is not necessary. This is usually the case in situations involving mass production. There are no cost centers and no differentiation between direct and overhead costs. The prime costs per cost unit can be determined by dividing the total costs of a given time period by the quantity of goods produced.

Multiple-stage division calculation

When performing single-stage division calculations, it is assumed that all of the goods produced will be sold. The expenses are not divided into production, administrative and marketing costs. Multiple-stage division calculations are used when there is a difference between the amount of goods produced and the amount of goods that are sold.

This type of division calculation is also used when a product passes through multiple production stations. The expenses incurred by each station are allocated according to the corresponding quantity of production.

Multiple-stage division calculation considers not only the changes in the inventory of finished products, but also the changes in the inventory of unfinished products. The prime costs of a produced unit are calculated when the unit is finished so that no rejected or defective products are counted and so that the individual materials are only used in the first cost center.

$$\text{Unit cost} = \frac{Production\ costs_1}{Production\ quantity_1} + \frac{Production\ costs_2}{Production\ quantity_2} + \frac{Administration+marketing\ costs}{Quantity\ sold}$$

Division calculation with equivalence numbers

This form of calculation is used with batch production. This means that the goods are the same except for minor differences such as size, material or production time. The goods are made comparable by using equivalence numbers which requires that common accounting units must be established.

The accuracy of this form of accounting is dependent upon the equivalence numbers. They should correspond exactly to the various cost factors.

Overhead calculation

Prime costs cannot be determined using division and equivalence number calculations in industrial operations with variable costs due to different kinds of products and manufacturing processes. Most companies produce a variety of products using a diverse array of manufacturing processes.

Overhead calculation is the appropriate accounting process to use for individual and series production. It requires a **separation** of the **direct costs** and **overhead costs**.

The **direct costs** are directly distributed among the manufactured units. The **overhead costs** are collected, sorted according to their causation and assigned as a percentage rate to production wages, production materials or to the sum of both.

The overhead calculation can be carried out in one of two forms:

Summarized overhead calculation is usually only used by small companies as it is an inexact calculation that does not require cost center accounting.

Differentiated overhead calculation.

Summarized overhead calculation

This is a rather simple but inexact accounting method. Cost center accounting is not necessary because the sources of costs are not in question. This method of accounting is only really usable when there are only a few overhead costs because the overhead costs are calculated as a single rate on the direct production material costs, production wage costs or on the combined total of the two. This means that there is only one adjustment rate. The overhead rate is determined as follows:

$$\frac{overhead\ costs\ x\ 100}{production\ material} \quad \text{or} \quad \frac{overhead\ costs\ x\ 100}{production\ wages} \quad \text{or} \quad \frac{overhead\ costs\ \ x\ 100}{production\ materials{+}wages}$$

Differentiated overhead calculation

The overhead costs are separated into materials, production, administration and marketing. It is possible to further separate the material and production into sublevels such as material 1, material 2, production 1 and production 2 and so on. This should allow for a very exact allocation of costs.

The rate percentages are determined in the expenses distribution sheet where the individual overhead costs are distributed accordingly.

Material overhead rate $= \frac{material\ overhead\ costs\ x\ 100}{direct\ material\ costs}$

Production overhead rate $= \frac{production\ \ overhead\ costs\ x\ 100}{direct\ production\ costs}$

Administrative overhead rate $= \frac{administrative\ overhead\ costs\ x\ 100}{direct\ administrative\ costs}$

Marketing overhead rate $= \frac{marketing\ overhead\ costs\ \ x\ 100}{direct\ marketing\ costs}$

Differentiated overhead calculation is characterized by at least three calculating fundamentals:

- **The production material**
- **The production wages**
- **The manufacturing costs**

When compared to summarize overhead calculations, this method results in much more exact prime costs. Cost center accounting is a necessary prerequisite for differentiated overhead calculation.

Let's refresh our memories a little:

Cost type accounting *Which costs?*	→	Staff Material
Cost center accounting *Where do costs come from?*	→	Administration Purchasing Production Sales
Cost unit accounting *Why are costs incurred?*	→	Products Services

Calculating hourly machine rates

When performing differentiated overhead calculations, a proportional relationship between the overhead costs of the four cost centers of material, production, administration and marketing and the individual supplemental bases of production material, production wages and cost of sales is assumed even though this is seldom the case in reality. This is the case when a machine is used during production that results in high costs:

The **goal of calculating hourly machine rates** is to distribute the costs associated with using a machine among the products that it was used for. This calculation differs from the differentiated overhead calculation only in determining the production costs.

Determining the production costs

As the machine-dependent costs are included in the hourly machine rate, the production overhead costs must therefore be divided into machine-dependent and machine-independent costs.

Machine-dependent overhead	Machine-independent overhead
Space costs Repair and maintenance costs Imputed depreciation Imputed interest Tool costs Energy costs	Wages Salaries Social costs Heating costs Other production overhead costs

In order to make the calculation of hourly machine rates within the production center possible, the production overhead costs in the expense distribution sheet need to be divided into machine-dependent and machine-independent costs. The following questions must be dealt with:

1. How is the machine runtime to be determined?
2. Which costs are machine dependent?
3. How can the hourly machine rate be calculated?

6.5 Cost behavior during changes in workload

As you can imagine, the total costs of a company are not fixed. They are heavily influenced by the amount of material and energy used, the number of workers, the size and efficiency of the administrative department as well as many other factors. Another important cost factor is the amount of work a company has.

Before looking at a few cost trends more closely, we should look at a few important terms that are used in cost accounting.

Operating level: The actual amount of production capacity used. This is measured in working hours, machine hours and output quantity (production units).

Total costs: The total costs incurred by a company for production within a given accounting period. This includes salaries, raw, operating and production materials, rents for production halls and energy costs.

Variable costs: Costs that vary according to the level of activity. They increase as production increases and vice-versa. Electricity costs are influenced by machine usage. Energy usage and costs are higher when machines run longer.

Fixed costs: Costs that remain constant regardless of the operating level. For example, the rent for a production hall does not change because of the amount of work that takes place within its walls.

Step costs: Costs that remain fixed within a range of productivity. For example, a production hall can handle a certain amount of work. If more work is required, then additional space must be rented. This means that rental costs remain constant up to a certain operating level. Beyond this operating level, this costs step upward or downward.

Marginal costs: A growth in total costs caused by the production of an additional unit.
Let's assume that the total cost for building 20 telescopes is €160,000. Producing an additional telescope would cost €5,600.
20 telescopes = €160,000
21 telescopes = €165,600 $\Rightarrow$ marginal cost of €5,600

Used capacity costs: The costs associated with the used capacity when manufacturing a product. For example, the usage of a machine costs €500 per hour.

Idle time costs: The costs incurred from unused capacity.
A machine that is not used incurs costs of €300.

Total cost per production unit: The total costs divided by the produced quantity of units.
For example, the total cost for building 17 telescopes is €136,000. €40,800 results from fixed costs and the rest comes from variable costs. The total cost per telescope is calculated by dividing €136,000 by 17 telescopes which results in a cost of €8,000 per telescope.

Fixed cost per production unit: The fixed costs divided by the quantity of units produced.
The fixed cost of €40,800 divided by 17 telescopes results in €2,400 in fixed costs per telescope.

Variable cost per production unit: The variable costs divided by the quantity of units produced.
The fixed cost of €95,200 (€136,000 total cost minus the €40,800 in fixed costs) divided by 17 telescopes results in €5,600 in fixed costs per telescope.

Mixed costs: Costs with fixed and variable components.
Electricity costs a set amount per used kilowatt hour. There is also a base monthly fee that has to be paid as well, regardless of how much energy is used.

7. CALCULATION PROCESS

There are a variety of methods that can be used to determine the prime costs or the sale price of a product. You should have no problem choosing the right method after working through this chapter.

7.1 Division calculation

Our head accountant would like to improve your understanding of three forms of division calculation: Single-stage division calculation, multiple-stage division calculation and division calculation with equivalence numbers.

Single-stage division calculation

This type of calculation is used in companies that have only one production center where a differentiation of the costs is not necessary. This is usually the case in situations involving mass production. There are no cost centers and no differentiation between direct and overhead costs. The prime costs per cost unit can be determined by dividing the total costs of a given time period by the quantity of goods produced.

Let's assume that our company is manufacturing filters and a total cost of €200,000 is incurred in producing 8,000 units. This results in a cost of €25 per unit.

$$\text{Cost per filter} = \frac{€200{,}00}{8{,}000\ units} = €25$$

Multiple-stage division calculation

When performing single-stage division calculations, it is assumed that all of the goods produced will be sold. The expenses are not divided into production, administrative and marketing costs. Multiple-stage division calculations are used when there is a difference between the amount of goods produced and the amount of goods that are sold.

ABC Inc. produced 500 widgets last year and sold 480 of them. The total production cost was €32,500 and the administration and marketing costs associated with the sale of the 480 widgets amounted to €3,744. The unit price is easy to calculate.

$$\text{Unit cost} = \frac{Manufacturing\ cost}{Quantity\ manufactured} + \frac{Administration\ and\ marketing\ costs}{Units\ sold}$$

In this case, this results in a unit cost of €72.80.

$$\text{Unit cost} = \frac{€\ 32{,}500}{500\ units} + \frac{€3{,}744}{480\ units} = €72.80/\text{unit}$$

This type of division calculation is also used when a product passes through multiple production stations. The expenses incurred by each station are allocated according to the corresponding quantity of production.

$$\text{Unit cost} = \frac{Production\ costs_1}{Production\ quantity_1} + \frac{Production\ costs_2}{Production\ quantity_2} + \frac{Administration+marketing\ costs}{Quantity\ sold}$$

Division calculation with equivalence numbers

This form of calculation is used with batch production. This means that the goods are the same except for minor differences such as size, material or production time. The goods are made comparable by using equivalence numbers which requires that common accounting units must be established.

Let's visit ABC Inc. again and take a look at some equivalence numbers.

ABC Inc. produces four varieties of eyepieces:

Table 7.1

Eyepiece 1	3,000 units	Equivalence number 1.0
Eyepiece 2	1,500 units	Equivalence number 0.7
Eyepiece 3	3,300 units	Equivalence number 2.3
Eyepiece 4	2,850 units	Equivalence number 1.8

The total cost amounts to €1,680,350. The proportional total costs as well as the unit costs will now be calculated.

Table 7.2

Type	Quantity prod.	Equiv. Number	Accounting units	Cost per accounting unit	Proportional total cost	Quantity produced	Unit cost
Eyepiece 1	3,000	1.0 =	3,000	x 100.20	= 300,600	: 3,000	= 100.20
Eyepiece 2	1,500	0.7 =	1,050	x 100.20	= 105,210	: 1,500	= 70.14
Eyepiece 3	3,300	2.3 =	7,590	x 100.20	= 760,518	: 3,300	= 230.46
Eyepiece 4	2,850	1.8 =	5,130	x 100.20	= 514,026	: 2,850	= 180.36
			= 16,770 Accounting units		1,680,354 Total cost		

You can determine the cost of each accounting unit by dividing the total costs by the accounting unit (there is a small rounding error).

$$\frac{€1{,}680{,}350\ total\ cost}{16{,}770\ accounting\ units} = €100.20 \text{ per accounting unit}$$

The accuracy of this form of accounting is dependent upon the equivalence numbers. They should correspond exactly to the various cost factors.

7.2 Overhead calculation

Summarized overhead calculation

This is a rather simple but inexact accounting method. Cost center accounting is not necessary because the sources of costs are not in question. This method of accounting is only really usable when there are only a few overhead costs because the overhead costs are calculated as a single rate on the direct production material costs, production wage costs or on the combined total of the two. This means that there is only one adjustment rate. The overhead rate is determined as follows:

$$\frac{Overhead\ costs\ x\ 100}{Production\ material} \quad \text{or} \quad \frac{Overhead\ costs\ x\ 100}{Production\ wages} \quad \text{or} \quad \frac{Overhead\ costs\ x\ 100}{Production\ material+wages}$$

Let's use an example to make this process clearer.

The following costs are incurred in an accounting period:

Production material	€120,000
Production wages	€140,000
Overhead costs	€195,000

The overhead allowance rates differ according to their corresponding bases.

Table 7.3

Basis	Formular	Overhead allowance rate
Production material	$\frac{195{,}000\ x\ 100}{120{,}000}$	= 162.50 %
or		
Production wages	$\frac{195{,}000\ x\ 100}{140{,}000}$	= 139.29 %
or		
Production material + wages	$\frac{195{,}000\ x\ 100}{260{,}000}$	= 75.00 %

The basis that best reflects the overhead costs should be selected.

When determining the prime costs of a product, the differences can be made clear when performing the calculations. A large component incurred costs of €1,800 for production material and €3,700 for production wages. This results in the following prime costs when using the overhead allowance rates that were calculated above:

Basis of production material **Overhead allowance rate 162.5%**

	Production material	€1,800.00	
	Production wages	€3,700.00	
=	Direct costs	€5,500.00	
+	Overhead costs	€2,925.00	162.5% of €1,800
=	Prime costs per unit	€8,425.00	

Basis of production wages **Overhead allowance rate 139.29%**

	Production material	€1,800.00	
	Production wages	€3,700.00	
=	Direct costs	€5,500.00	
+	Overhead costs	€5,153.73	139.29 % von €3,700
=	Prime costs per unit	€10,653.73	

Basis of production material + wages **Overhead allowance rate 75%**

	Production material	€1,800.00	
	Production wages	€3,700.00	
=	Direct costs	€5,500.00	
+	Overhead costs	€4,125.00	75% of €5,500
=	Prime costs per unit	€9,625.00	

You can see that there are large differences between the prime costs.

Differentiated overhead calculation

The overhead costs are separated into materials, production, administration and marketing. It is possible to further separate the material and production into sublevels such as material 1, material 2, production 1 and production 2 and so on. This should allow for a very exact allocation of costs.

The rate percentages are determined in the expenses distribution sheet where the individual overhead costs are distributed accordingly.

Material overhead rate $= \frac{Material\ overhead\ costs\ x\ 100}{Direct\ material\ costs}$

Production overhead rate $= \frac{Production\ overhead\ costs\ x\ 100}{Direct\ production\ costs}$

Administrative overhead rate $= \frac{Administrative\ overhead\ costs\ x\ 100}{Direct\ administrative\ costs}$

Marketing overhead rate $= \frac{Marketing\ overhead\ costs\ x\ 100}{Direct\ marketing\ costs}$

As we have already looked at this process while discussing preliminary and final pricing, we will now simply look at the complete procedure.

Production material
\+ Material overhead costs
= Material costs
Production wages
\+ Production overhead costs
\+ Special direct costs of production
= Production costs
= Product manufacturing cost
\+ Inventory reduction
– Inventory increase
= Cost of sales
\+ Administration overhead costs
\+ Marketing overhead costs
\+ Special direct costs of marketing
= Prime cost of the job
\+ Profit margin
= Preliminary selling price
\+ Agent's commission
= Cash selling price
\+ Customer account
= Target selling price
\+ Customer rebate
= List price, offer price

Differentiated overhead calculation is characterized by at least three calculating fundamentals: The production material, the production wages and the manufacturing costs. When compared to summarized overhead calculations, this method results in much more exact prime costs. Cost center accounting is a necessary prerequisite for differentiated overhead calculation.

7.3 Preliminary and final pricing

Preliminary and final costing is carried out with the help of cost object accounting. Preliminary costing is carried out before the project begins. The costs are estimated for the purpose of tendering an offer. The direct costs can be calculated relatively accurately and the overhead costs are calculated using average values. This stage will provide you with enough information to decide whether or not to take on a job.

Let's look at a simple example from ABC Inc. The preliminary pricing for the manufacture of a machine contains the following positions:

	€	€
Production material	2,000.00	
+ 10% material overhead costs	200.00	
Material costs		2,200.00
Production wages	850.00	
+ 150% Production overhead costs	1,275.00	
Production costs		2,125.00
= Manufacturing costs		4,325.00
+ 25% Administration overhead costs		1,081.25
+ 5% Marketing overhead costs		216.25
= Prime costs of the job		5,622.50

The profit margin, customer account, agent's commission and customer rebate might also need to be calculated as well. The following formula would be used to include them:

Prime cost of the job	5,622.50				
+ 10% Profit margin	562.25				
= Preliminary sale price	6,184.75	=	95%		
+ 3% Agent's commission	195.31	=	3%		
= Cash selling price	6,380.06	=	98%		
+ 2% Customer account	130.21	=	2%		
= Target selling price	6,510.27	=	100%	=	94%
+ 6% customer rebate	415.55			=	6%
= List price 6,925.82				=	100%

It should be noted that the calculations are to be made with the correct base value (100% or reduced base value).

The final costing contains the actual costs and you will be able to compare them with the preliminary numbers. These numbers can be analyzed to ensure or improve the economic viability of your business operations.

Let's look at another example that has resulted in the following actual costs and overhead allowance rates:

Production material €2,200, production wages €920, actual overhead allowance rate for material 8%, production overhead allowance rate 140%, administration 22% and marketing 6%.

A binding offer price of €6,925.82 was tendered. Let's look at the changes.

Table 7.4

	Preliminary pricing			Final pricing		
Cost type	**%**	**Amount**	**Total**	**%**	**Amount**	**Total**
Production material		2000.00			2200.00	
+ Material overhead costs	10	200.00		8	176.00	
= Material costs			2,200.00			2,376.00
Production wages		850.00			920.00	
+ Production overhead costs	150	1,275.00		140	1,288.00	
= Production costs			2,125.00			2,208.00
= Manufacturing costs			4,325.00			4,584.00
+ Administrative overhead	25		1,081.25	22		1,008.48
+ Marketing overhead	5		216.25	6		275.04
= Prime costs of the job			5,622.50			5,867.52
+ Profit margin	10		562.25	**5.41**		**317.23**
= Preliminary selling price			6,184.75		➔	6,184.75
+ 3% Agent's provision			195.31			
= Cash selling price			6,380.06			
+ 2 % Customer account			130.21			
= Target selling price			6,510.27			
+ 6% Customer rebate			415.55			
= List price			6,925.82			6,925.82

The profit margin decreased from 10% to 5.41% due to the increase in costs. The next offer will take these higher costs into account.

The differences between the preliminary and final costing can be easily summarized. The preliminary pricing works with target costs that are determined from past experience and is used to prepare a preliminary offer price. The final pricing includes the actual costs incurred in the production of the goods and is used for determining the final selling price.

Preliminary pricing = Bid estimate. This process is carried out before production is started and is based on **anticipated costs** which are also known as **target costs** and include the planned direct costs and standard overhead costs.

Final pricing is a checking process that compares the target costs from the preliminary pricing with the actual costs incurred in the project. The actual success of a project is determined by comparing the final numbers with the target numbers.

8. CALCULATING THE HOURLY MACHINE RATE IN FULL-COST ACCOUNTING

When calculating the differentiated overhead allowance rate, a proportional relationship between the overhead costs of the four cost centers of material, production, administration and marketing and the corresponding overhead rate fundamentals of production material, production wages and cost of sales is assumed even though this is seldom the case in the real world. This occurs when a machine is used in production that incurs high costs.

The hourly machine rate is calculated to distribute the cost of using a machine among the manufactured products by looking at the time associated with its use. Calculating the hourly machine rate differs from the differentiated overhead calculation only in the **determination of the production costs**.

8.1 Determining the production costs

As the **machine related costs** are considered in the hourly machine rate, the production overhead costs should be next divided into machine-dependent and machine-independent overhead costs.

Machine-dependent overhead	Machine-independent overhead
Space costs	Wages
Repair and maintenance costs	Salaries
Imputed depreciation	Social costs
Imputed interest	Heating costs
Tool costs	Other production overhead costs
Energy costs	

In order to make the calculation of hourly machine rates within the production center possible, the production overhead costs in the expense distribution sheet need to be divided into machine-dependent and machine-independent costs. The following questions must be dealt with:

1. How is the machine runtime to be determined?
2. Which costs are machine dependent?
3. How can the hourly machine rate be calculated?

8.1.1 Determination of the machine runtime

The machine runtime is calculated as follows

Total machine time
– Down time
– Maintenance time
= **Machine runtime**

The **total machine time** is the number of hours that the machine could run if it was put into uninterrupted operation. The machine runtime for a coming accounting period is calculated as follows: 365 days x 24 hours = 8,760 hours.

Down time is defined as those times that the machine is not used due to holidays, weekends or times when there is no production work being carried out. A company that is only open 8 hours a day would have 16 hours of machine down time per day.

Maintenance time can be allocated according to the manufacturer's recommendations and past experience.

A machine operates for an average of 37.5 hours in a 40 hour work week. The remaining 2.5 hours are used to clean and make adjustments to the machine. It can be used fully for 48 weeks a year. The monthly machine runtime can be calculated as follows:
37.5 x 48 : 12 = 150 machine running hours.

8.1.2 Determination of the machine-dependent costs

a) Machine acquisition cost: €240,000
Machine replacement cost: €288,000
Expected service life: 12 years
Depreciation: linear

b) The capital invested in the machine should be subject to 8% imputed interest. The interest should be applied to the original acquisition cost which means that the yearly depreciation should be taken into account. This would result in an interest rate that decreases every year and the accounting would thus be inconsistent. In order to have the interest rate remain constant, the interest rate on the machine should be applied at half of the original acquisition price over the course of the machine's service life.

c) The machine uses 20 kW of energy per hour. The cost of 1 kWh is € 12. The monthly base charge for electricity is €40.

d) The machine requires 20 m^2 of working space. The imputed building depreciation is €150 per month per m^2.

e) The repair and maintenance costs are estimated to come to €15,000 annually. Half of these costs are considered to be fixed costs and half are considered to be variable costs.

f) The monthly cost of tools is set to €300.

g) The cost of operating material is set to €600 per month.

8.1.3 Calculating the hourly machine rate

Table 8.1

Machine-dependent production overhead costs	Calculation		Cost per month
1. Imputed depreciation	$\frac{288{,}00}{12\ x\ 12}$	=	€2,000
2. Imputed interest	$\frac{240{,}000\ x\ 8\%}{2\ x\ 100\%\ x\ 12}$	=	€800
3. Energy costs	20 x 0.12 x 150 + 40	=	€400
4. Space cost	150 x 20	=	€3,000
5. Repair and maintenance	15,000 : 12	=	€1,250
6. Tools			€300
7. Fuel costs			€600
Total overhead costs			€8,350
Hourly machine rate	8,350 : 150	=	€55.67

Let's expand our view to include one more aspect. When there are varying operating levels, it is usually very important to differentiate between fixed and variable costs. This is illustrated in the following example.

A new machine with a value of €307,200 is acquired. The replacement cost for the machine is 25% higher. The machine has an expected service life of 8 years. The following factors also apply: 120 hours average monthly runtime, 8% imputed interest on half of the acquisition value, €180 space cost for each m^2/year with 20 m^2 of total space usage, €12,000 maintenance costs/year (30% of which is a variable cost), €540 tool cost/month (100% variable), 20 kW energy use/hour at €.22 per kWh (100% variable), imputed depreciation is calculated linearly from the replacement cost (100% fixed).

This results in the following table:

Table 8.2

Machine-dependent Production overhead costs	Monthly fixed production overhead costs in €	Monthly variable production overhead costs in €
Imputed interest	1,024.00	
Calculated depreciation	4,000.00	
Energy		528.00
Space costs	300.00	
Maintenance	700.00	300.00
Tool costs		540.00
Total	6,024.00	1,368.00
Cost per hour at 120 hours/month	50.20	11.40

With an average monthly runtime of 120 hours, this results in an hourly machine rate of:

Variable costs/hour	11.40
Fixed costs/hour	50.20
Hourly machine rate	61.60

Now we will raise the operating level to 135 hours. The hourly machine rate changes as follows:

Variable costs/hour	11.40
Fixed costs/hour = €6,024 : 135 hours	44.62
Hourly machine rate	56.02

Now we will lower the monthly machine running hours to 85.

Variable costs/hour	11.40
Fixed costs/hour = €6,024 : 85 hours	70.87
Hourly machine rate	82.27

The variable hourly machine costs do not change because they are dependent on the operating level (constant unit cost). Fixed machine costs are another matter. They decrease as usage decreases and vice-versa.

9. OUTLINE OF THE BREAK-EVEN ANALYSIS

You have certainly heard discussions relating to the specific revenue that must be generated or to the specific quantity of products that must be sold in order to cover costs. This discussion will be covered here. The **break-even analysis** has many applications and can make business decisions much easier.

As you are already aware, expenses can be divided into fixed and variable costs. Fixed costs are unrelated to the operating level and are therefore more significant when there is nothing being produced. Variable costs are closely tied with the operating level of the company and therefore play a large role in determining the success of a business. These costs usually increase proportionally to the operating level.

The break-even analysis is the most common form of marginal costing (because only the portion of the variable costs independent of the fixed costs are considered) and, as opposed to full cost accounting (e.g. overhead allowance rate calculation), takes the operating level of the business into account. As this method analyzes the proportional relationship between costs and operating level, it is very useful in production and sales planning.

The **gross margin** or **marginal return** of product lines are determined by subtracting the variable costs from their corresponding revenue sources while the fixed costs are not considered.

The most important formula in break-even analysis is:

Revenue/unit
– Variable cost/unit
= Marginal return/unit

9.1 Break-even analysis in the form of unit accounting

The simple accounting formula is as follows:

Selling price
– Variable unit cost
= Marginal return per unit
– fixed costs per unit
= Profit per unit

Let's assume that every widget sold results in revenues of €320 and variable costs in the amount of €170. The difference of €150 is used to cover the fixed costs and to contribute to operation profits. If this €150 is more than the amount of money required to cover the fixed costs, this amount represents the marginal return.

As soon as the price at which the product can be sold is lower than the fixed cost per unit, then the company will generate losses because any additional revenues will not cover the additional costs that the project generates. Projects with these kinds of numbers should not be taken on.

The lowest price limit would be the amount required to generate enough revenue to cover the fixed costs exactly. The marginal return would be zero in this case.

Price subtracted by the variable cost per unit	Price > variable cost per unit	Price < variable cost per unit	Price = variable cost per unit
↓	↓	↓	↓
Marginal return per unit	Positive marginal return	Negative marginal return	Lower price limit

9.2 Break-even analysis in the form of periodic accounting

The appropriate formula is as follows:

Accounting period revenue
– Variable costs per accounting period
= Marginal return
– Fixed costs of the accounting period
= Profit of the accounting period

The company profits are determined by subtracting the total fixed costs from the total marginal return over an entire accounting period.

This is relatively easy to calculate for a company that produced only one product. Let's look at a company that only produces widgets. The total fixed costs in an accounting period amount to €80,000 and the variable costs per widget come to €65. 650 widgets were sold at a unit price of €200. The total production capacity is 720 units.

The marginal return and the operating result for the accounting period are easy to calculate.

	Revenue	650 units x €200 =	€130,000
–	Variable costs in the Accounting period	650 units x €65 =	€42,250
=	Marginal return	650 units x €135 =	€87,750
–	Fixed costs of the accounting period		€80,000
=	Accounting period profit		€ 7,750

9.3 Determination of the break-even point

The break-even point can be determined easily. The following sentence explains the concept of the break-even point:

The break-even point is reached when the total costs are covered by the total amount of revenue.

The break-even point can be easily determined from the break-even analysis.

The marginal return is the difference between revenue and the variable unit cost and is a sort of preliminary profit per unit that is used to settle the fixed costs. A real profit is only attained when the sum of the marginal returns exceed the sum of the fixed costs.

In our example, the total amount of fixed costs comes to €80,000. The marginal return per unit comes to €135. How many widgets must be sold to cover the fixed costs?

Marginal return x units = total fixed costs

Formula adjustment!

Units = total fixed costs : marginal return

€80,000 in fixed costs : €135 marginal return = €593 units

The break-even point is reached with 593 widgets. Every additional widget sold results in a profit in the amount of the marginal return.

This concept is illustrated by the following formula:

Break-even point = fixed costs : marginal return/unit

9.4 Break-even analysis in a single-product business

Determining the marginal return and the break-even point in a single-product business is relatively easy.

As previously discussed, the marginal return per unit is calculated by subtracting the variable unit cost from the unit sale price. We can demonstrate this with a few numbers:

	Widget sale price	€120
–	Variable unit cost	€90
=	Marginal return per widget	€30

A marginal return of €30 covers the fixed costs or generates profit if there have been enough sales. In this example, 300 widgets were sold and the fix costs amount to €12,000.

	Net revenue	300 widgets x €120	€36,000
–	Variable costs	300 widgets x €90	€27,000
=	Total marginal return	300 widgets x €30	€9,000
–	Fixed costs		€12,000
=	Losses		€3,000

The marginal return on the 300 sold widgets is not sufficient to cover the fixed costs which results in a loss for this accounting period.

How many widgets would have to have been sold to cover the fixed costs?

$$\frac{€12{,}000\ Fixed\ costs}{€30\ marginal\ return/widget} = 400 \text{ widgets}$$

With €12,000 in fixed costs and a marginal return of €30 per widget, 400 widgets must be sold to reach the break-even point. Every additional widget sold increases the company profits.

420 widgets were sold in the next accounting period. Let's see what this results in:

	Net revenue	428 widgets x €120	€51,360
–	Variable costs	428 widgets x €90	€38,520
=	Total marginal return	428 widgets x €30	€12,840
–	Fixed costs		€12,000
=	Profit		€840

You can see that the situation has improved. The profit/loss situation of a company is influenced by sales numbers. When sales decrease, customers can be invited to tour the company. Advertising campaigns can be improved and visiting customers can make your company more attractive or memorable. The amount of widgets that will need to be sold to cover these marketing costs can be easily determined using break-even analysis.

9.5 Effects of changes in operating level, costs and prices

When a business is expanded, a new set of fixed costs come into play. This means that a new product with new marginal return or multiple products with the current marginal return must be sold to cover this cost. The break-even point changes because there is now a different amount of units that must be sold in order to cover the fixed costs.

The effect of changes in operating level on profits has already been discussed. Let's look at an example of this as well as examples of the effects of changes in price and cost.

The initial situation has fixed costs of €220,000 in the accounting period. 3,900 widgets with a net price of €90 are sold. The variable costs are €25/unit.

	Net revenue	3,900 widgets x €90	€351,000
–	Variable costs	3,900 widgets x €25	€97,500
=	Total marginal return	3,900 widgets x €65	€253,500
–	Fixed costs		€220,000
=	Profit		€ 33,500

Now we will simply change the amount of sales in the accounting period.

	Net revenue	3,300 widgets x €90	€297,000
–	Variable costs	3,300 widgets x €25	€82,500
=	Total marginal return	3,300 widgets x €65	€214,500
–	Fixed costs		€220,000
=	Loss		€5,500

How many widgets must be sold to cover the fixed costs?

$$\frac{Fixed\ costs}{Marginal\ return\ per\ unit} = \frac{€220{,}000}{€65} = 3{,}385 \text{ widgets}$$

The break-even point is reached at 3,385 widgets.

Let's look at the initial situation again but this time we will change the unit price. The net price of a widget is increased to €110 and the fixed costs remain unchanged.

	Net revenue	3,900 widgets x €110	€429,000
–	Variable costs	3,900 widgets x €25	€97,500
=	Total marginal return	3,900 widgets x €65	€331,500
–	Fixed costs		€220,000
=	Profit		€111,500

The situation has greatly improved because the marginal return has increased. Let's look at the opposite case where the net price has decreased to €75.

	Net revenue	3,900 widgets x €75	€292,500
–	Variable costs	3,900 widgets x €25	€97,500
=	Total marginal return	3,900 widgets x €50	€195,000
–	Fixed costs		€220,000
=	Loss		€25,000

The marginal return per widget decreases as the selling price decreases as long as the variable costs remain unchanged.

Now we will change the variable costs. In the first case, they will increase to €34 per widget.

	Net revenue	3,900 widgets x €90	€351,000
–	Variable costs	3,900 widgets x €34	€132,600
=	Total marginal return	3,900 widgets x €56	€218,400
–	Fixed costs		€220,000
=	Profit		€1,600

In the next example the variable costs decrease to €18 per widget.

	Net revenue	3,900 widgets x €90	€351,000
–	Variable costs	3,900 widgets x €18	€70,200
=	Total marginal return	3,900 widgets x €72	€280,800
–	Fixed costs		€220,000
=	Profit		€60,800

In the next variation, we will increase the fixed costs of the accounting period to €260,000.

	Net revenue	3,900 widgets x €90	€351,000
–	Variable costs	3,900 widgets x €25	€97,500
=	Total marginal return	3,900 widgets x €65	€253,500
–	Fixed costs		€260,000
=	Loss		€6,500

By instituting new efficiency measures, it was possible to reduce the fixed costs to €160,000.

	Net revenue	3,900 widgets x €90	€351,000
–	Variable costs	3,900 widgets x €25	€97,500
=	Total marginal return	3,900 widgets x €65	€253,500
–	Fixed costs		€160,000
=	Profit		€93,500

It is possible to create different combinations of unit prices, sales numbers, fixed costs and so on. Perhaps you would like to try some combinations of your own.

SUMMARY

Full cost accounting

Full cost accounting records all the costs in an accounting period and offsets them against this period's operational performance. It assumes that a company's total costs for maintaining its existence must be covered for the long term. Full cost accounting therefore makes no individual cost coverage checks for individual production runs. The detailed surcharge calculation works with full costs regardless as to whether they were used as preliminary or follow-up calculations.

Disadvantages of full cost accounting:

Full cost accounting does not always take market data (e.g. market prices) into consideration. This results in only provisional price or performance changes that correspond to market situations being able to be considered in the full cost accounting. This would result in increasing unit costs if there were a decrease in units being produced because the fixed costs must be distributed among a smaller number of cost units.
In the case of changes in activity levels, the offsetting of fixed costs in full cost accounting leads to a pricing policy that is not in line with the market.

$c = \frac{C_{fix}}{a} + c_v$

c = Cost per piece
C_{fix} = Fixed total costs
A = Produced quantity
c_v = Variable costs per piece

An example:
How do the production costs per piece change when 16,000 instead of 20,000 pieces are produced when taking the following information into account: Fixed total costs are €260,000 and the variable cost per piece is €1.20.

Production costs per piece at
20,000 pieces: $\frac{€\ 260{,}000.00}{20{,}000\ pieces}$ *+ €1.20 = 14.20*

16,000 pieces: $\frac{€\ 260{,}000.00}{16{,}000\ pieces}$ *+ €1.20 = € 17.45*

Direct costing

Direct costing requires that all types of costs are checked for their dependency on the production and then categorized as variable or fixed costs. Direct costing requires that only a portion of the costs, in this case at least the variable production costs, are covered.

Revenues
– Variable production costs
= Marginal return

Marginal return is the share of a cost unit for covering the company's total fixed costs.
The higher the marginal return of every product, the more the block of fixed costs will be covered.

	Sale price per piece	€15.50
–	Variable cost per piece	€9.50
	Marginal return per piece	€6.00

Representation of the break-even point
The break-even point (or critical point) refers to the output level necessary to cover all the costs (fixed and variable costs) of a company.

An example:

Sale price per piece	€600.00
Total fixed costs	€100,000.00
Variable cost per piece	€400.00

The mathematical determination of the break-even point can be found at the amount of produced pieces that results in neither a profit nor a loss (where the costs and revenues are the same). The following therefore applies:

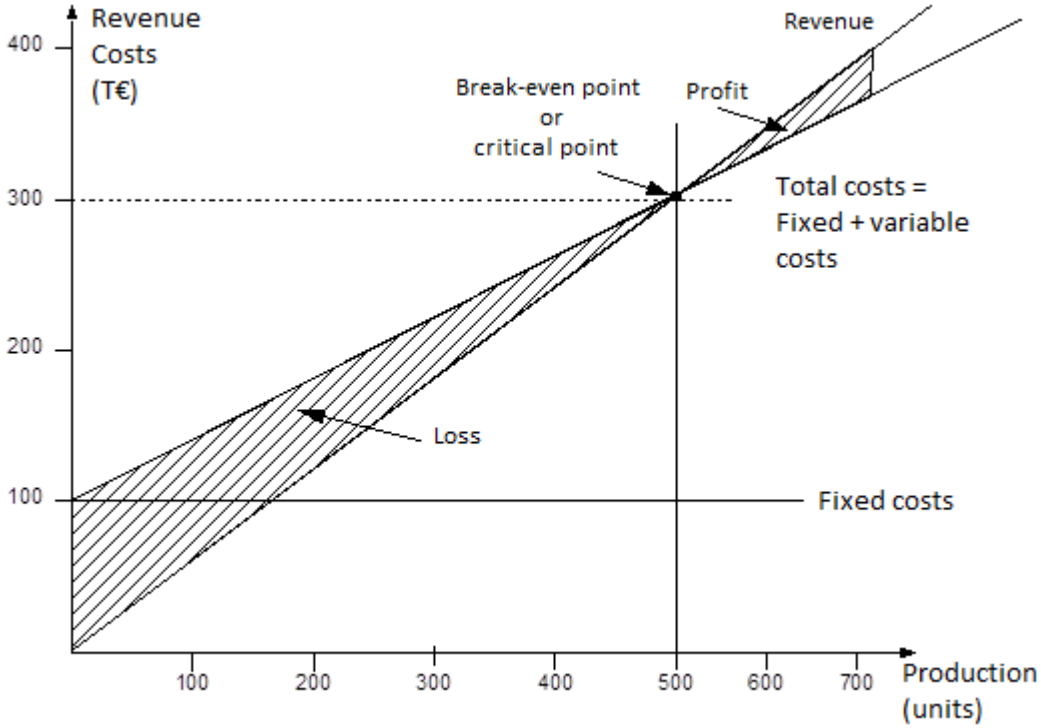
R = Tor R – T = 0 (R = Revenues, T = Total costs)

The following also applies: $R = r \cdot a$ und $T = C_{fix} + C_{var} \cdot x$
(r = Revenue per piece, k_{var} = variable unit cost)

Entering our numbers results in the following:

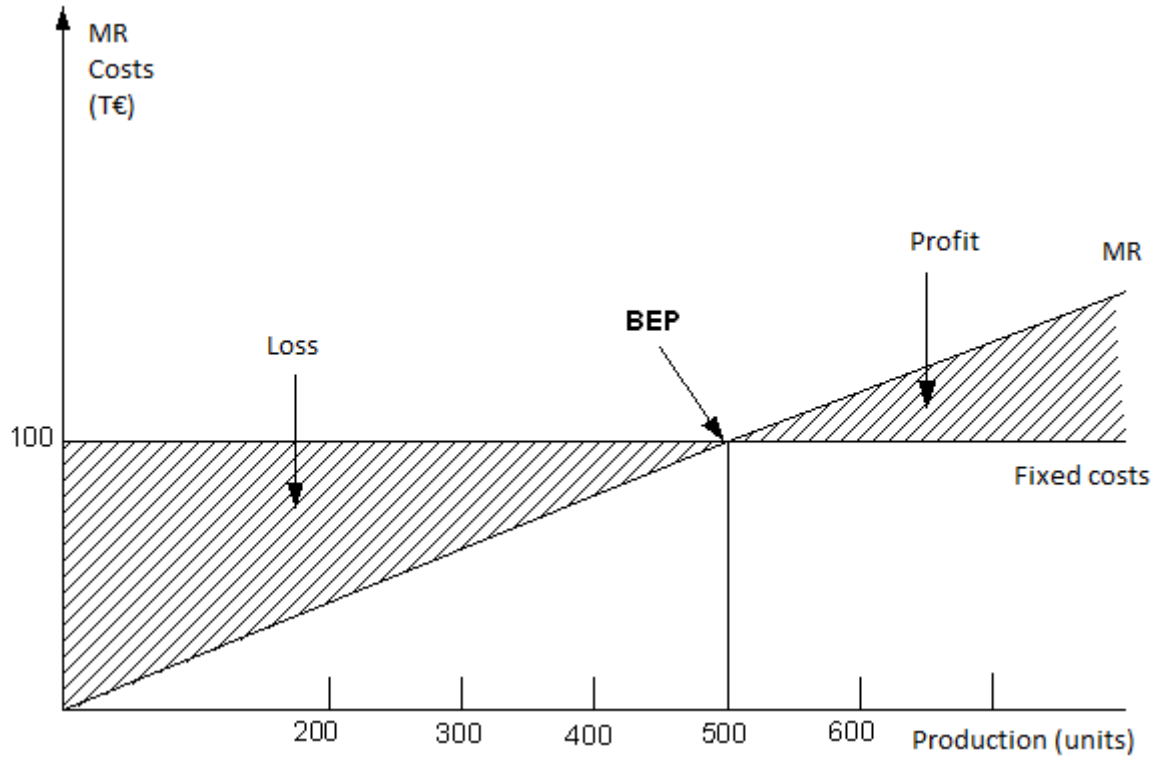
600.00 x	= 100,000.00 + 400,00 · x
600.00 x – 400 x	= 100,000,00
200 x	= 100,000,00
x	= 500 pieces

Graphical representation:



This chart shows that the critical point is reached at an output level of 500 units, at 400 units there is a slight loss and at 600 units there is a noticeable profit. Fixed costs in the amount of €100,000 are assumed at a production level of 0 units.
The chart also shows that the variable costs increase proportionally to increased production but the total costs only increase under proportionally to production levels.

If we calculate the break-even point using the marginal return calculation, we can generate the following chart:



Since the marginal return per piece results from the subtraction of the variable costs from the sales revenue, this positive result can be paid into the block of fixed costs. The break-even point therefore lies at the amount of pieces needed to result in a total marginal return that equals the fixed costs

$MR = C_{fix}$	Total marginal return = Fixed costs
$DB = mr \cdot x$	Total marginal return = Unit marginal return · Quantity
$C_{fix} = mr \cdot x$	Fixed costs = Unit marginal return · Quantity
$x = \frac{C_{fix}}{mr}$	Quantity = Fixed costs: Unit marginal return

With our numbers:

Marginal return per unit	= €600.00 – €400.00 = €200.00
Break-even point	$= \frac{€100{,}000.00}{€200.00}$ = 500 units

An output level of 500 units results in the full costs being covered.