Contents

1. Logistics

1.1 Procurement logistics

Procurement logistics is located at the start of the logistical chain and regulates the planning, control and deployment of purchased materials with regard to the flow of material and information. This means that "procurement logistics" includes the suppliers, external transport and shipping, inventory administration and portions of the internal transport and preparation needed for production.

The main objective of procurement logistics is the "provision of materials and parts according to the production program (time schedule, quantity and quality) at minimum cost." (Sommerer, p. 32)

Some preparatory work must be carried out in order to satisfy these requirements. An **ABC analysis** should be carried out to give an overview of the values of both purchased parts and parts produced internally.

An ABC analysis makes the following possible:

- The separation of important issues from peripheral ones
- Focusing on important economical areas
- Creation of transparency
- The determination of standards of comparison
- Achievement significant savings in inventory management

The classification of the individual positions is subject to the determination of various selected thresholds, reference parameters or the number of groups and thus there are various corresponding defined ranges defined in specialist literature:

A position: 60 – 85% of the value, 10 – 20% of the quantity and/or positions

B position: 10 – 15% of the value, 20 – 35% of the quantity and/or positions

C position: 5 – 15% of the value, 45 – 70% of the quantity and/or positions

The ABC analysis can be used to help make decisions as to how to prioritize and carefully handle important materials, positions, critical parts or safety components.

It can also be used in determining the value/quantity of produced and used materials to aid in making decisions in the following areas:

The access frequency and rate of turnover of the inventory, quantity revenue of suppliers, observance of delivery dates, quantity and value of orders, observance of quality standards, quantity and value of complaints, proportion of the total revenue of the company, etc.

The ABC analysis is often combined with the **XYZ analysis** which takes consumption and/or prediction accuracy into account.

This combination allows conclusions to be drawn regarding things such as the ability of JIT (just in time) production (AX and BX goods).

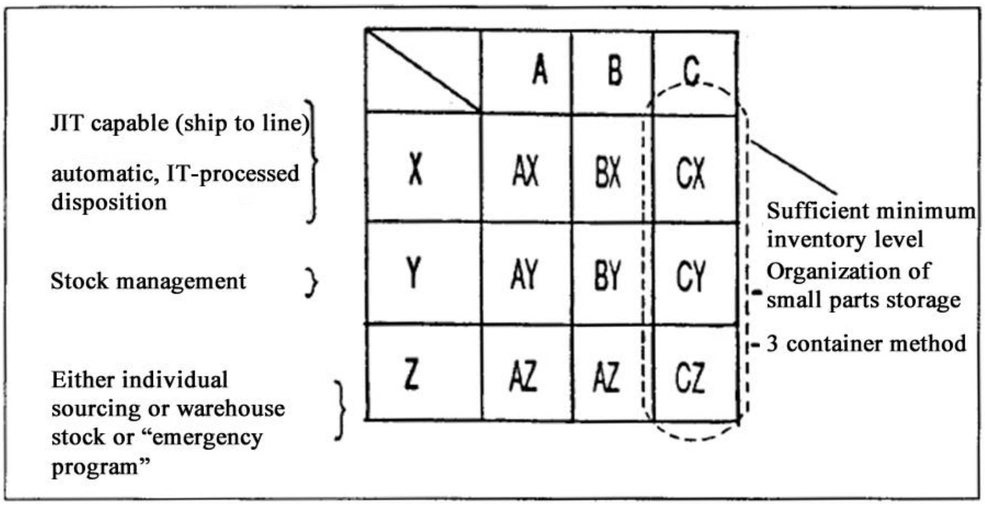


Figure 1: Material allocation strategy

A selection of the appropriate method of determining demand can be made based in the classification made in the ABC analysis.

The knowledge of future demand is the basis for optimally allocating materials. The calculation can be made with the help of three processes:

- **Determinative** (future oriented) demand assessment for A components, critical or safety components.
- **Stochastic** (past oriented) demand assessment for B and C components.
- **Subjective** estimation if there is no available data.

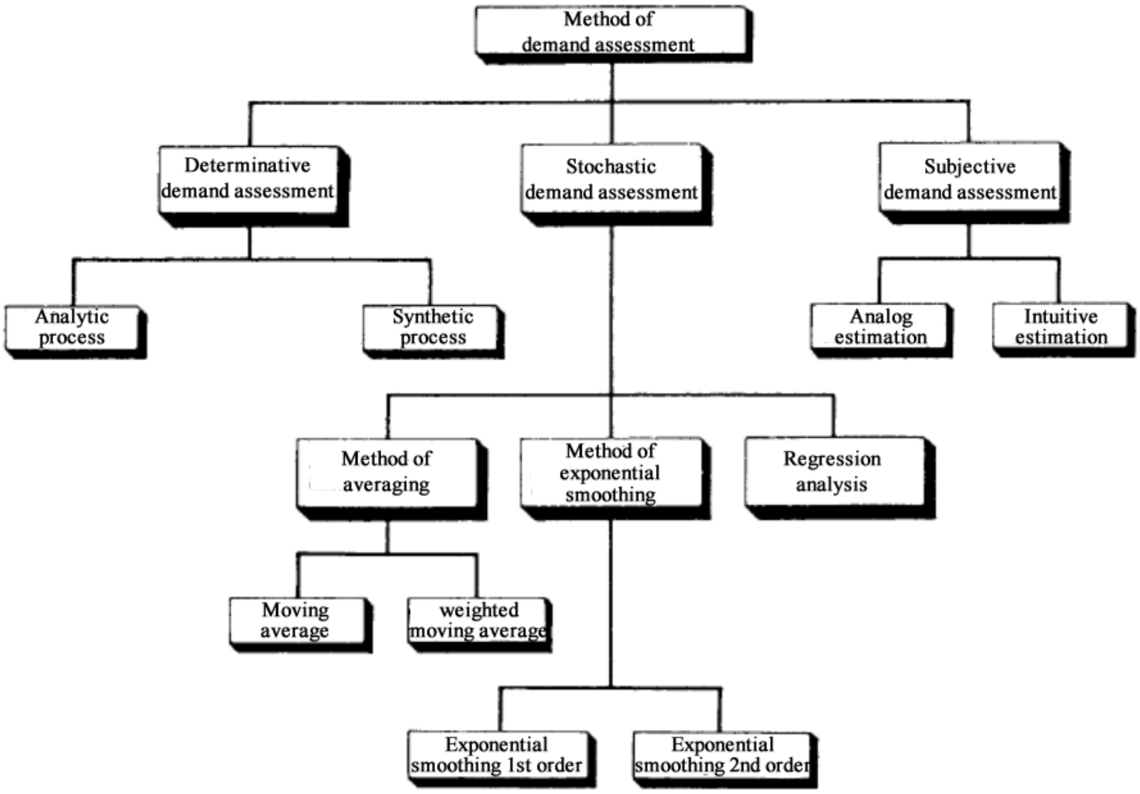


Figure 2: Methods of assessing demand

The net and gross demand is then determined for calculating stock.

Another important aid in making decisions in the framework of order quantity calculation is the determination of the **optimal order quantity** as defined by Karl Adler. This calculates the amount of material that would have to be ordered to keep the total cost stemming from procurement costs and warehousing costs to a minimum according to the following formula:

This chart shows the opposing cost trends.

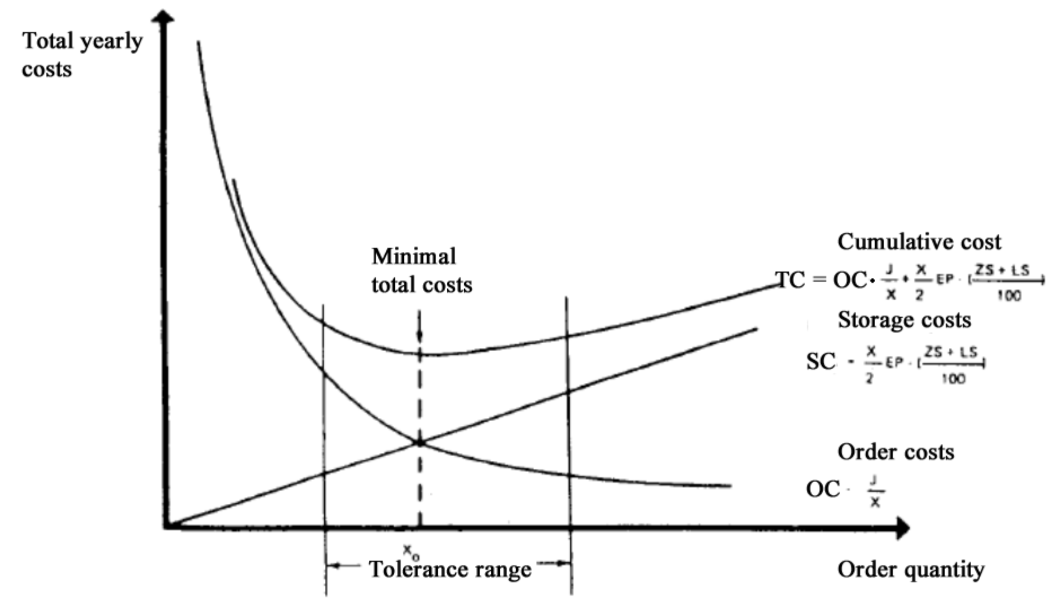


Figure 3: Graphic representation of the optimal order quantity

Before we look at individual procurement logistic strategies like lean production or make or buy, we must look at some fundamentals regarding the administration of inventory and internal transport.

- The department for storage logistics has the task of making sure that all types of storage, commissioning and transport of materials (umbrella term for manufacturing supplies, component groups, individual parts and products) from receiving to shipping is handled continuously without problems and at optimal cost.

  At this point we must shortly discuss the functions of packaging. Packaging should be used to transport, promote, inform, store, protect and economize. The last point is especially important in regard to waste logistics.

  Storage can perform balancing, security, speculative and refinement functions.

  Specific storage strategies must be developed such as how centralized storage should be, whether storage should be handled in-house or in external locations, how automated the storage facility should be, what the principles of putting materials into and taking materials out of storage should be and the selection of the accounting (evaluation, consumption and inventory) and information systems.

  Furthermore, criteria for selecting the optimal warehouse location, criteria for judging storage costs and their potential for cost reduction as well as the determination of the appropriate type of storage (main warehouse, pallet warehouse, etc.) and storage systems (e.g. floor storage, pallet high bay storage, shelving) must be defined.

- According to DIN 30781, in-house transport systems have the task of transporting objects within the company and between factories. This transport is carried out within one location of between multiple locations. The instruments that are used for such transport that is not carried out by external transport services are designated as **means of conveyance**.

  Means of conveyance are divided into two groups known as continuous conveyors (e.g. roller conveyors, chain conveyors or bucket conveyors) and discontinuous conveyors (e.g. lifting units such as elevators or cranes and ground conveyors such as forklifts and unmanned transport systems).

  Auxiliary conveyor materials such as pallets of all types, boxes, barrels and cartons are also used.

1.1.1 Economic effects of scaling back the in-house production depth in accordance with “lean production”

Lean production, within the scope of **lean management** (streamlining the entire company), is understood as measures taken to streamline the production logistics. This can mean customer-oriented production with fewer workers and lower inventory that reduces costs and still keeps the customers satisfied. The reduction of the in-house production depth also means that larger quantities of many design variations are also possible.

Area of application	Application related objective	Possible instruments
Product development	- Shortening the time span between product development and product launch - Market-oriented objective cost planning - Integration of suppliers into product development	- Simultaneous engineering - Project management - Interdepartmental cooperation (team work) - Cost improvement process
Procurement/supply chain	- Shortening delivery time - Inventory reduction - Integration of suppliers into the production chain - Integration of external transport services into the process chain	- Modification of a supplier to a system supplier including having hits own responsibility for research and development - Procurement of delivered parts using dual sourcing with a centralized supply (reduces the disadvantages associated with single sourcing) - JIT (just-in-time) delivery - Procurement logistic control
Production/factory operations	- Flow-oriented process planning - Modular production and assembly structure - Zero error production - Increase in the production team´s responsibility in the process	- Businesswide/productionwide logistical control - Lean manufacturing/Production segmenting/modular factory - Kanban control in connection with JIT - Total quality management/quality engineering - Organizational improvements, organization is more important than automation (simple is best) - Continuous improvement/Kaizen (Japanese for improvement)
Disposal and customer service	- Expansion of customer relations management - Deconcentration of multistage channels of distribution - Customer oriented service - Taking over product disposal and recycling	- Differentiated market observation - Key account management - Early adoption of customer demands and requests into the modular product and process structure - Further development of logistical service providers so that they become system service providers with direct relationships with the customer
Organization and personnel	- Creation of flat hierarchies - Team organization and management - Deconcentration of differentiated task assignments - Flexible possibilities for personnel allocation	- New assignments of responsibilities in the teams - Removal of selected management levels in the company hierarchy - Job rotation and further qualifications

Figure 4: Application fields, objectives and instruments for implementing lean production

> "The reduction of in-house production depth, the associated increase in complexity of the production area and the modified supplier market have led to the implementation of adapted sourcing strategies by the companies that are streamlining to take advantage of cost-saving possibilities. They have the goal of simplifying the diversity of supplier relationships, increasing the transparency of the procurement process and reducing the total costs of order fulfilment and they define how many sources of supply they want to maintain for a delivered component." [Heiserich, P. 32]

The relationship between the economic significance and the complex procurement situation of the sourcing strategies in connection with the ABC classification is shown by the next chart:

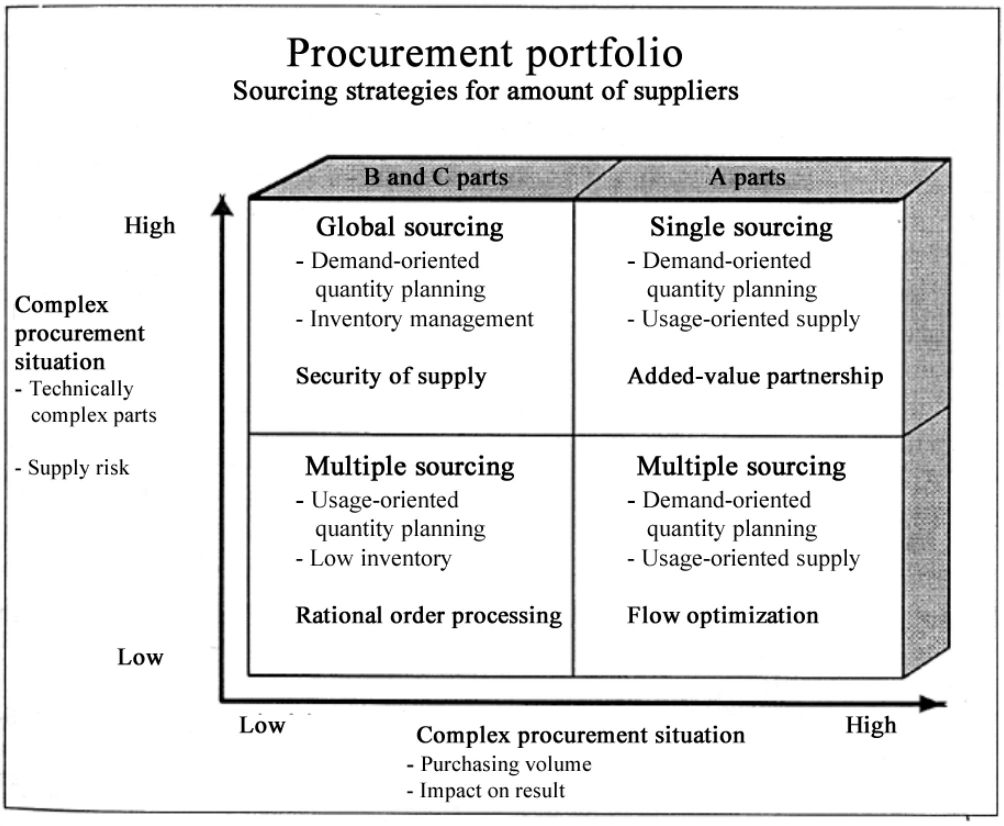


Figure 5: Procurement portfolio

1.1.2 Advantages and disadvantages of a MOB (Make or buy) decision

The decision between producing something in-house or externally is dependent on an array of business-relevant criteria.

Alongside the reduction of the in-house production depth and the concentration on the core business, there are other economic and technical criteria that are important when making a MOB decision.

Economic criteria:

- The cost of purchasing the part is lower than it would cost to manufacture it in house.
- The marginal return per piece or the time-related profit margin for the part is too low.
- The cost of storage and the cost of the in-house transport greatly influence the total cost per piece.
- High servicing and customer service costs are incurred for the production of individual parts and component groups.
- Other related factors.

Technical/technological criteria:

- Insufficient in-house know-how.
- Insufficient production capacity.
- The machinery on hand does not meet the technical requirements of the part.
- The purchased parts are of higher quality than those produced in house.
- Other related factors.

1.1.3 Production-synchronous component delivery (JIT system)

More than 40 years ago Toyota set up a system of material flow according to the “supermarket principle” = usage-oriented flow of material. This meant that when a part was removed from inventory, the resulting hole in the stock was to be filled. This resulted in the birth of the KANBAN system. The success and inventory turnover rate resulted in flexibility and great delivery service. In the beginning of the 1980s, this concept was implemented in the United States and Europe and was called the **just-in-time principle (JIT)**. The main goal of JIT is the reduction of inventory and the shortening of lead times.

Alongside individual sourcing and inventory sourcing, JIT is one of the three procurement principles.

> “One of the most important examples the connection between procurement and production is JIT production. Resources are only allocated when they are really needed. This procurement concept can reduce inventories to nothing in extreme cases. This leads to the reduction in capitalization and other inventory costs and avoids having obsolete parts in inventory. People had been aware of the principle of production-synchronous procurement even before its general implementation but only after the integrated structuring of production and procurement processes was implemented could JIT production be made economical.” [Weber, P. 16]

Furthermore, there should not only be cooperation between procurement and production, but development as well. These relationships should also be passed on to the customers and the suppliers in order to encourage collaborative development.

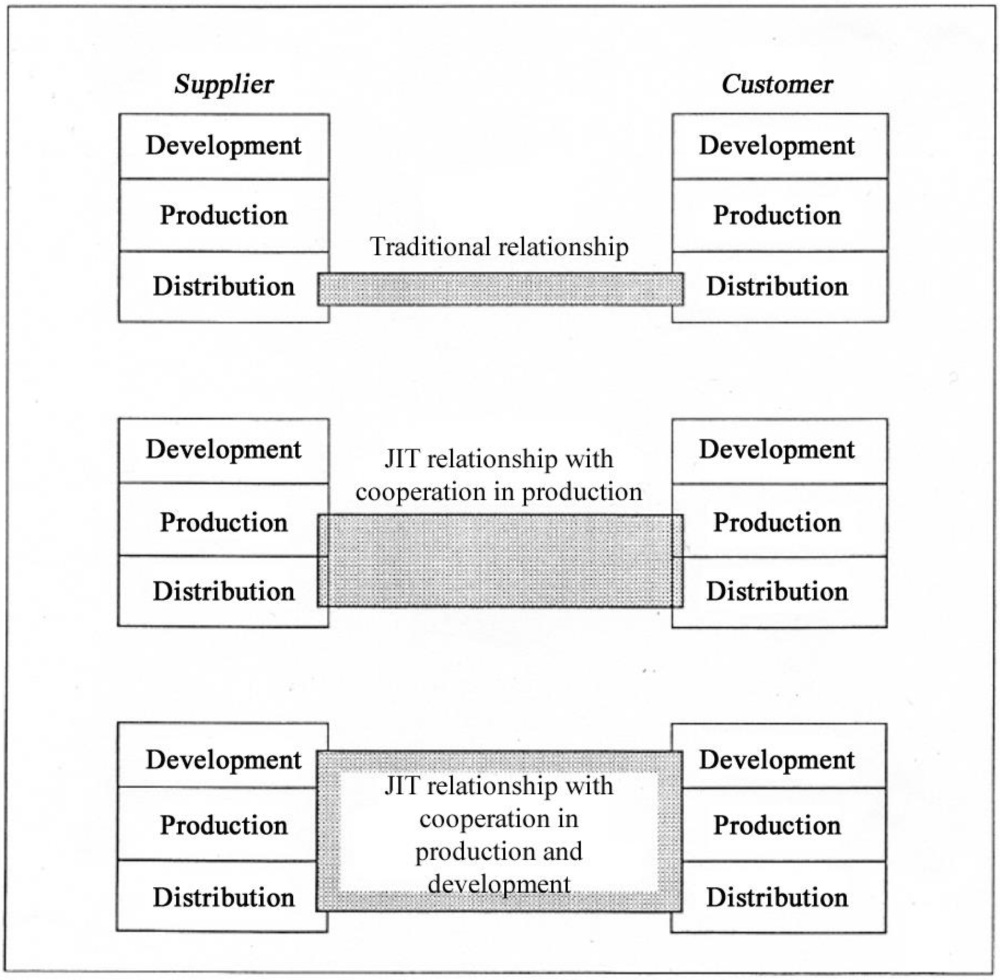


Figure 6: Interfaces in customer/supplier relationships

There are three distinct phases within the framework of purchasing: The initiation of procurement (with a request, offer and comparison of suppliers), procurement negotiations (contract negotiations, writing up of a contract and order confirmation) and the procurement processing (schedule review and receipt of goods).

In order to cooperate with suppliers optimally, there should be a defined order quantity. This is carried out using a master agreement that defines a long-term quantity to be delivered. The quantities can be distributed over a period of time based on a forecast and can be cleared for delivery on call.

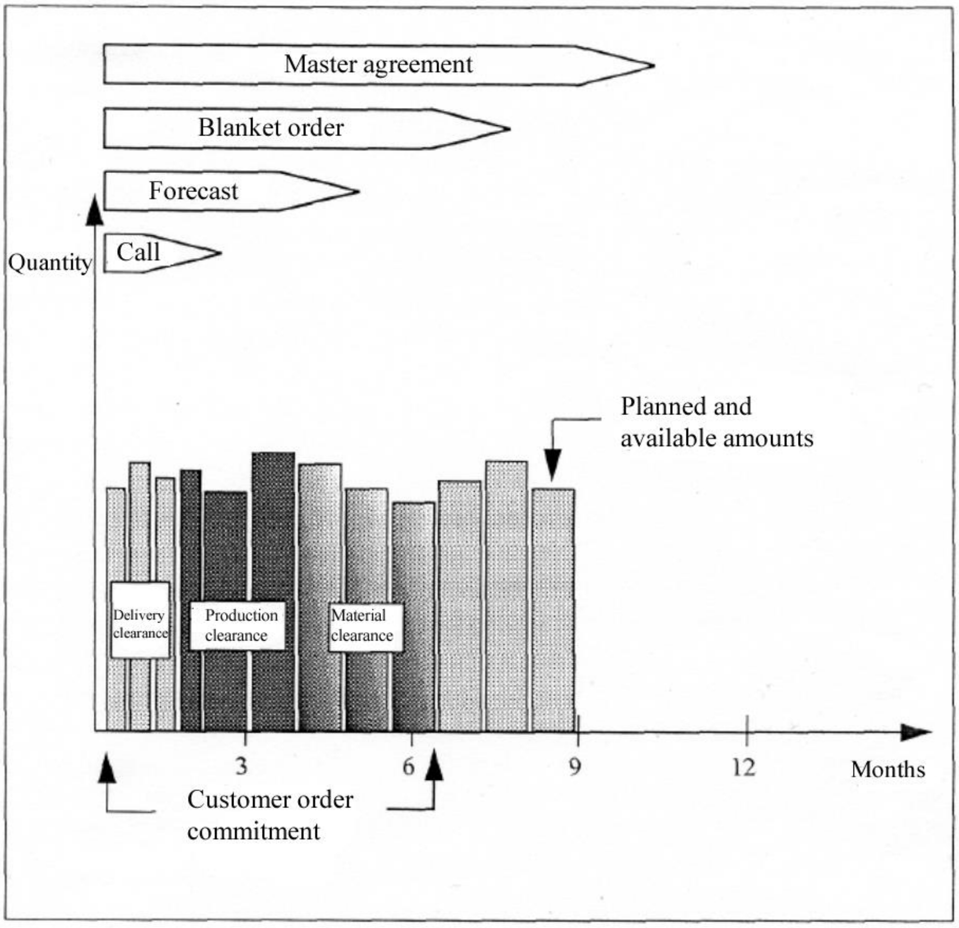


Figure 7: Concrete steps defined in the master agreement

JIT delivery and JIT production must be differentiated in order to facilitate a deeper understanding of the concepts.

JIT delivery includes the material, external transport using any necessary means up until the internal transport and handover of the required goods at the location where they will be used.

JIT production begins when the material is received and continues through the production and finishing phases.

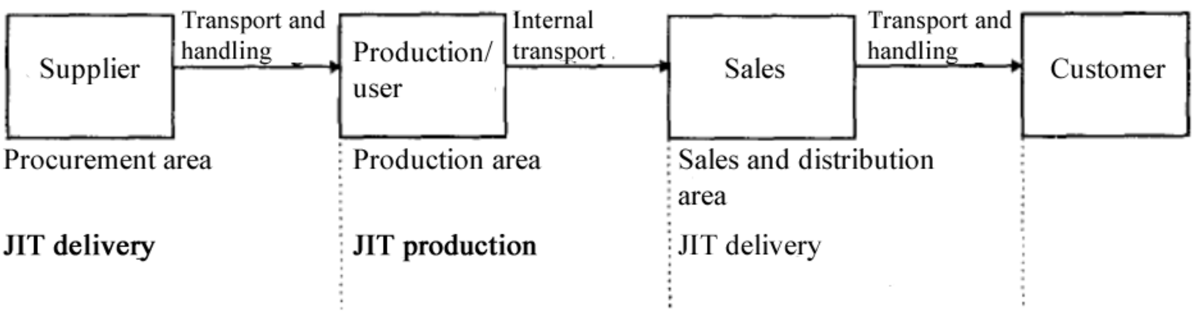


Figure 8: Designation of the JIT areas

We should also look at additional JIT applications:

- JIT in sequence (sequentially oriented allocation)
- JIT in blocks (allocation is carried out in individual, type-specific units)
- JIT in mix (allocation of various materials in a single shipment carrier)

Typical conditions of JIT are short lead times on delivery calls, prioritization, reliability, competence and discipline of all the contractual partners.

Furthermore, the following principles are to be observed: Supplier delivery call unit/production unit = transport unit = storage unit = usage unit.

This means that the supplier packages the units in such a way so that the units can be used in production immediately and without any additional repacking of the goods.

Additional agreements must be made between the supplier and the customer regarding the responsibility for quality control. This allows for ship to stock, shit to line or line to line deliveries (there are inventory and inspection-free deliveries) to be agreed upon.

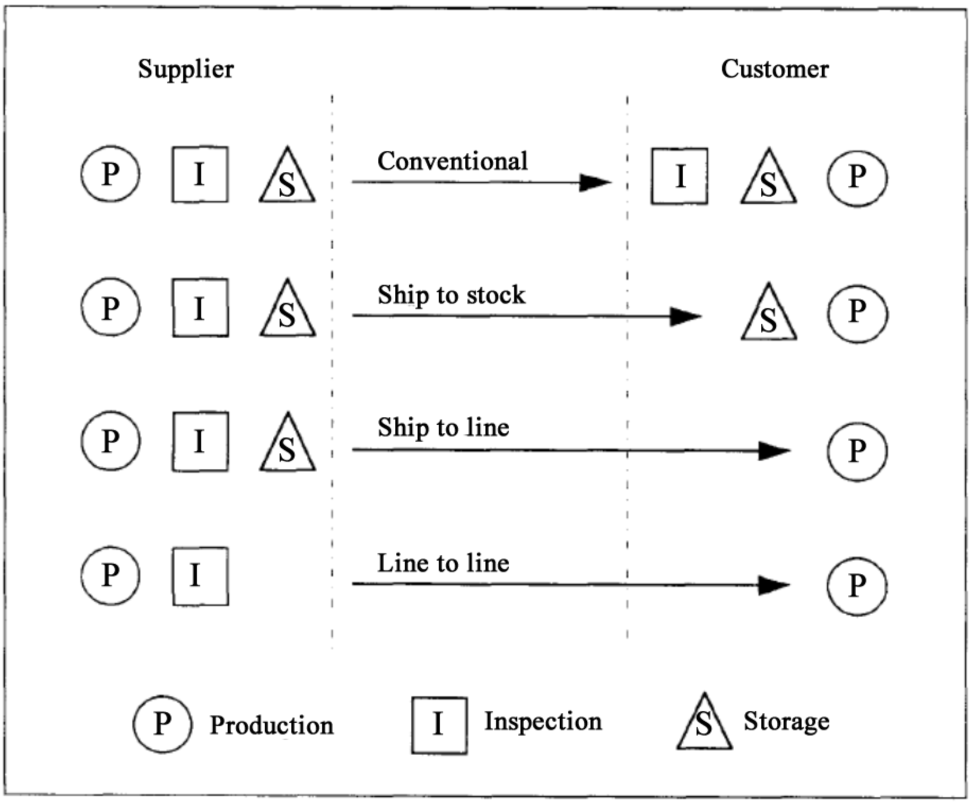


Figure 9: Supply strategies

The line to line strategy used by Audi in their factory in Ingolstadt is structured as follows:

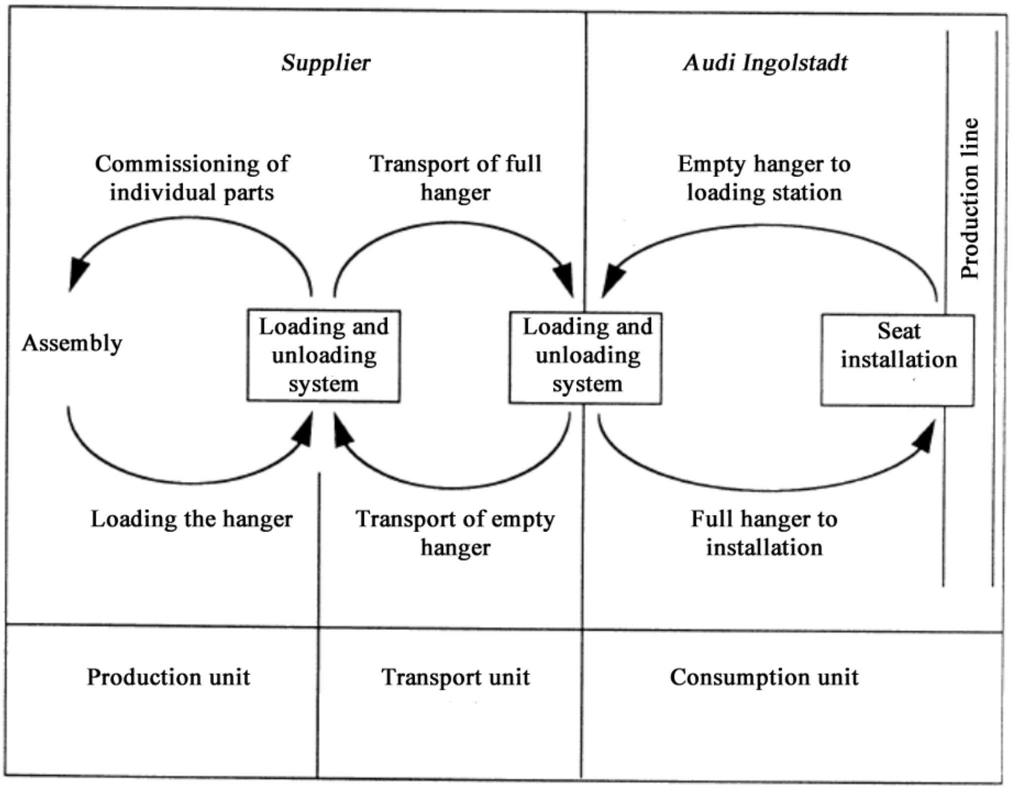


Figure 10: Line to line delivery at Audi Ingolstadt

1.1.4 Performance problems and the resulting consequences

The requirement of "safety of supply" would usually lead to a high level of inventory. The fast reaction to customer requirements means even higher levels of storage costs. In order to deal with these issues, a company's goal should be to minimize the manufacturing door-to-door times of materials to keep capital commitments low.

An important goal should be to avoid malfunctions and disruptions of every kind. Disruptive factors can stem from material, personnel, operating materials and the lack of important information. Any of these factors could lead to interruptions or impediments in operation and usually cause high costs to be incurred in fixing the problem.

There are various ways to avoid or discover possible problems before they happen by doing things such as having a companywide suggestion system, analysing past problems or by carrying out SPCs (statistical process control) or other statistical procedures.

The goal should be to uncover every problem in advance and deal with the avoidable ones and make emergency procedures for those that cannot be avoided. Problems that cannot be fully avoided are things such as natural disasters, embargos, strikes, the bankruptcy of a supplier or customer as well as a host of legal issues. Although these issues cannot be fully prevented, it would be smart to have contingency plans in place should they occur.

Type of problem	Examples
Worker-related problems	– Worker sickness – Accidents on the job – Strikes and lockouts – Large decreases in worker performance
System-related problems	– Machinery breaking down due to defects – System downtime due to power interruption – Technical defects on the machines, measuring units, etc. – Delay due to maintenance work – Errors in CNC programs
Material-related problems	– Defective materials – Incorrect material measurements – Mix-ups of materials – Insufficient supply of materials
Scheduling problems	– Incorrect production documentation – Problems in scheduling, and quality and process planning – Incorrect production hall documentation – Lack of feedback from completed orders

Figure 11: Types of problems

Companywide objectives - High level of customer satisfaction - High revenues - High flexibility - High adherence to schedules and high level of supply readiness - Low level of production space commitments - Low direct and indirect costs in all areas of the company - Low external transport and handling costs - Low costs for packaging and conservation - Transparent and rational information sharing - Low planning costs - High sense of responsibility in all levels of the company			
Procurement - High material and component availability - Low procurement time - Low procurement costs - Low amount of material handling - Low inventory levels	**Production** - High productivity - Low set-up times - Low material lead times - High usage of capacity - Low quality control costs - Low levels of downtime	**Sales** - Fast reaction to customer requirements - Effective information flow	**Transport / Distribution** - Low transport costs - Simplification of movement of goods

Figure 12: Summary of important objectives

1.2 Production logistics

According to Sommerer, the goal of production logistics is to continually produce goods for customer orders while minimizing both the level of inventory and production costs.

This means that the required quantity and quality of goods should be produced as inexpensively as possible while still meeting the delivery schedule and with the production capacity being used as much as possible with minimal inventories while still respecting the social interest of the workers.

The type and quantity of the goods that are to be produced are a very important factor for determining what the production layout and material flow should be. Another important criterion is the **in-house production depth** (level of internal production as compared to externally purchased components).

In order to optimally achieve the goals of production logistics, decisions must be made as to the types of production and organization.

1.2.1 Production areas according to logistical, integrated, process oriented and interdepartmental factors

Jobs and predictions are handled in the process planning and control area.

Production planning heavily influences how economically production will be carried out. The goal is to have the lowest possible production costs per unit produced by selecting inexpensive materials and appropriate working procedures, methods and conditions and also by drawing up complete and understandable instructions for the production department. Furthermore, the establishment of working procedures and the deployment of sufficient numbers of workers and materials is also handled in production planning.

The task of **production control** is to adhere to all the established procedures that are necessary to complete the work.

> "The control unit is based on the results of planning. As soon as a work order, whether in-house or from a customer, is on hand, the control unit must ensure that there is sufficient capacity (workers and materials), components and information. During the production process, the control unit monitors the working processes and compares the actual information with the target information. If there are deviations, the control unit must quickly step in to avoid damage to people, resources and materials thereby ensuring that the work is carried out with minimal costs, with sufficient quality and on schedule. The goal of the control unit is to make sure that the work is completed on time, with a minimal amount of working time and that the production capacity is optimally used."
> [Gummersbach, P. 313]

The following diagram illustrates the path of a work order up until the monitoring of production and also shows the interfaces and interactions within the company structure.

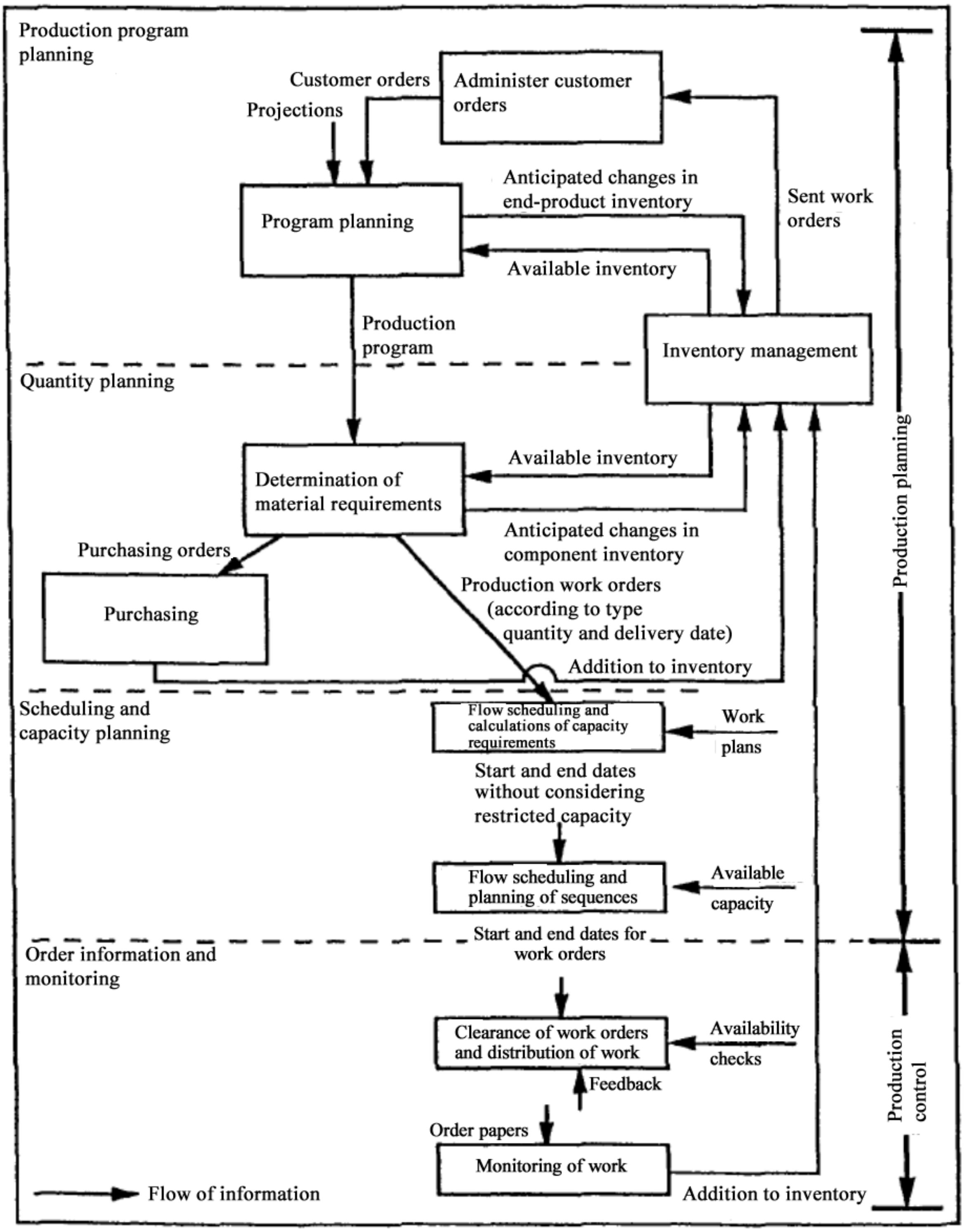


Figure 13: Functions of the production planning and control

1.2.2 Information and communication systems for production, storage and information systems

Market driven planning, manufacturing and monitoring of products require that all the task-relevant information is quickly made available to the production logistics team in consultation with the other operating spheres. These requirements only apply when the manufacturing department has access to data and communication processing systems.

- **Production planning and control systems**
  According to REFA (a German association concerned with performing work studies), production planning and control systems, PPCS, includes computer supported systems for organizational planning, control and monitoring of the production processes from creation of an offer until delivery while considering the aspects of quantity, scheduling and capacity.

  The goals of PPCS are the realization of short production times, adherence to schedules, optimal inventory levels as well as the economic allocation and use of operating resources.

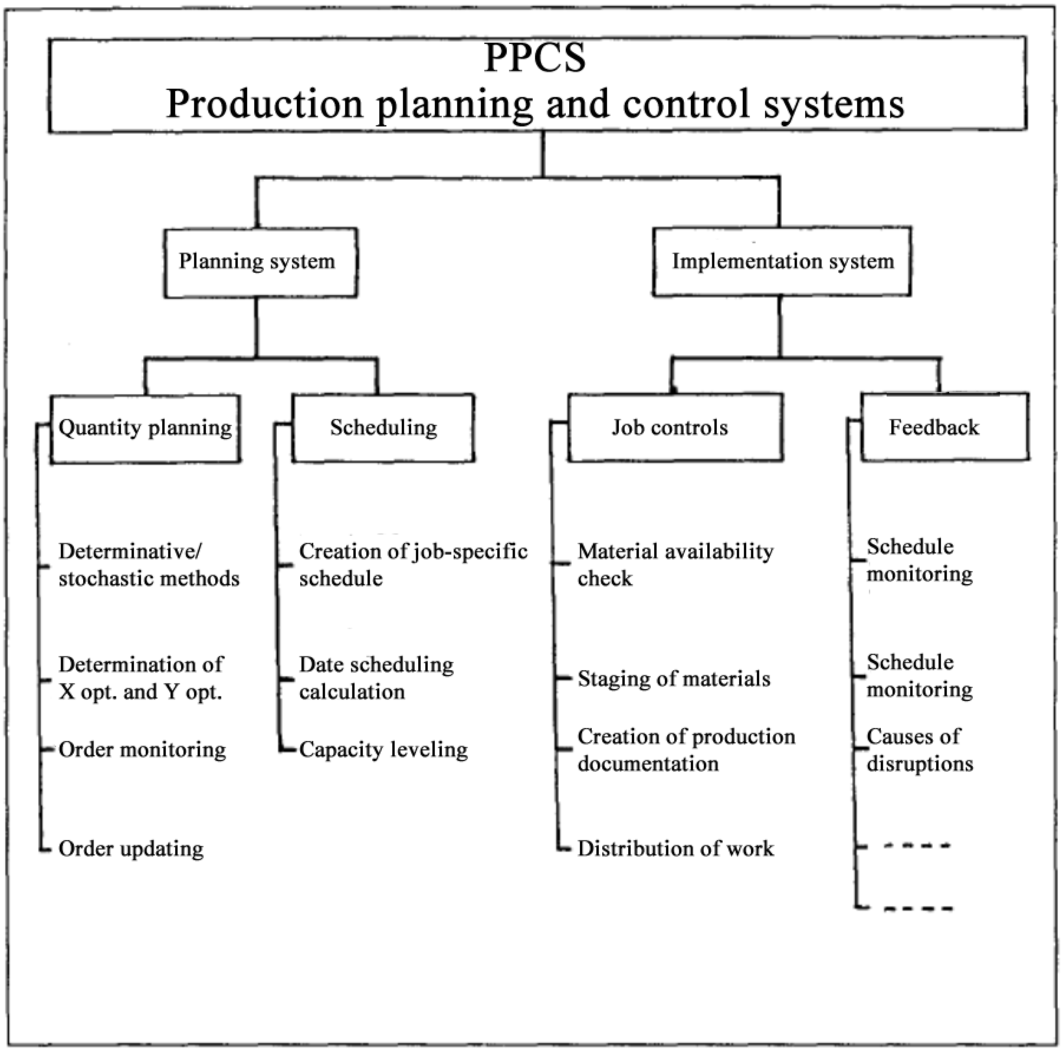


Figure 14: Subtasks of production planning and control

A total summary including interfaces and possible conflicts of interest is illustrated in figure 15.

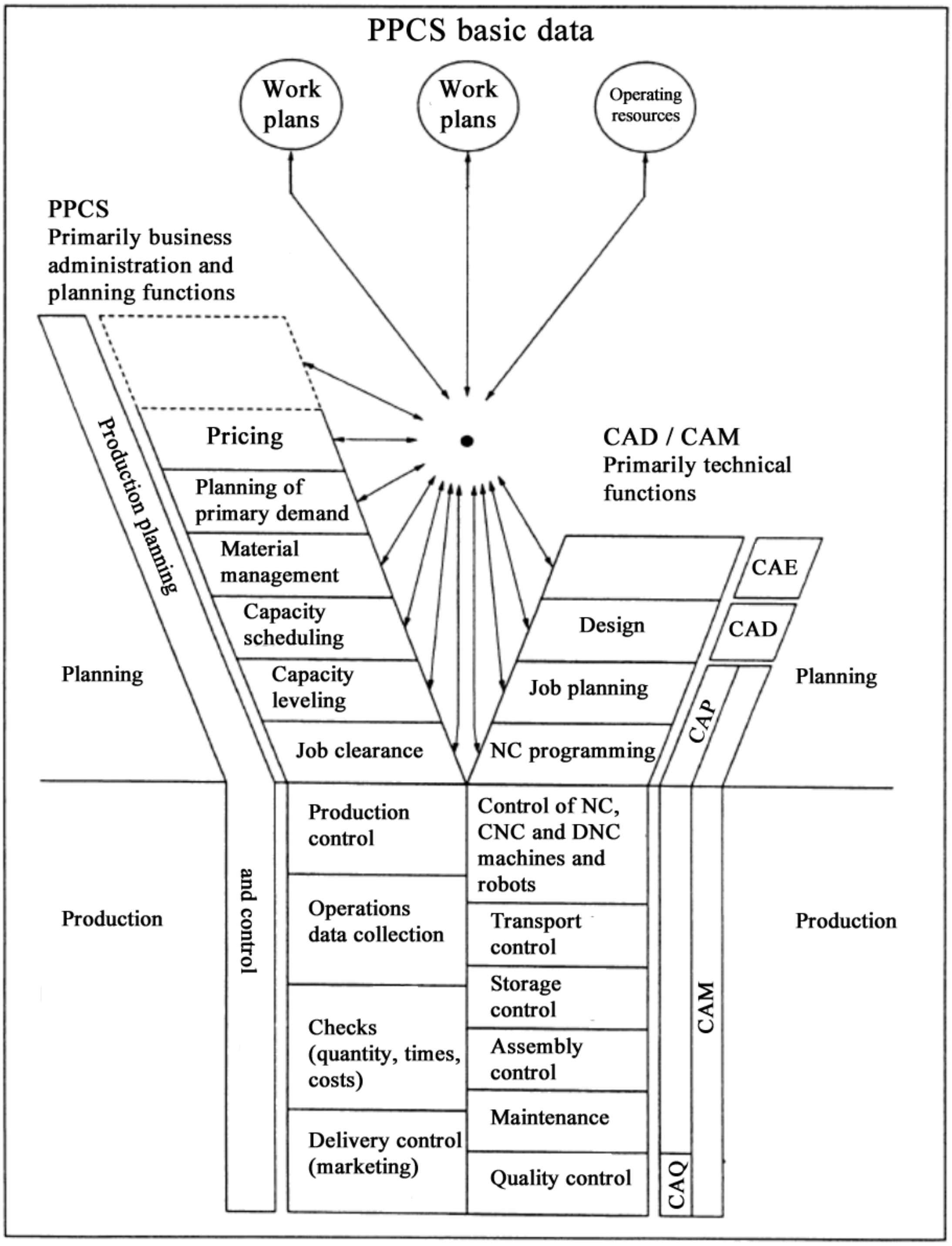


Figure 15: Levels and areas of CIM-PPC systems

- **CAD**: Computer aided design is the design and development on the screen of a computer.
- **CAP**: Computer aided planning: Work planning including all the documentation used in production.
- **CAM**: Computer aided manufacturing is the technical control and monitoring of operating resources during the manufacture of a product.
- **CAQ**: Computer aided quality planning and quality control using IT systems.
- **CIM**: Computer integrated Manufacturing: CIM includes the interaction of the CAD, CAM, CAQ and PPC systems. The objective is to integrate the technical and organizational functions for product manufacturing into one common and commonly accessible database.

1.2.3 Production and manufacturing procedures

As we have already covered briefly, the principle of **KANBAN** is to reduce inventory levels and production times. This Japanese term translates to card or sign.

> "The KANBAN control principle implements interconnected self-controlling informational regulating feedback systems within a production group for the intra-company job assignments and material flow up to the point of delivery according to a customer order." [Sommerer, P.52]

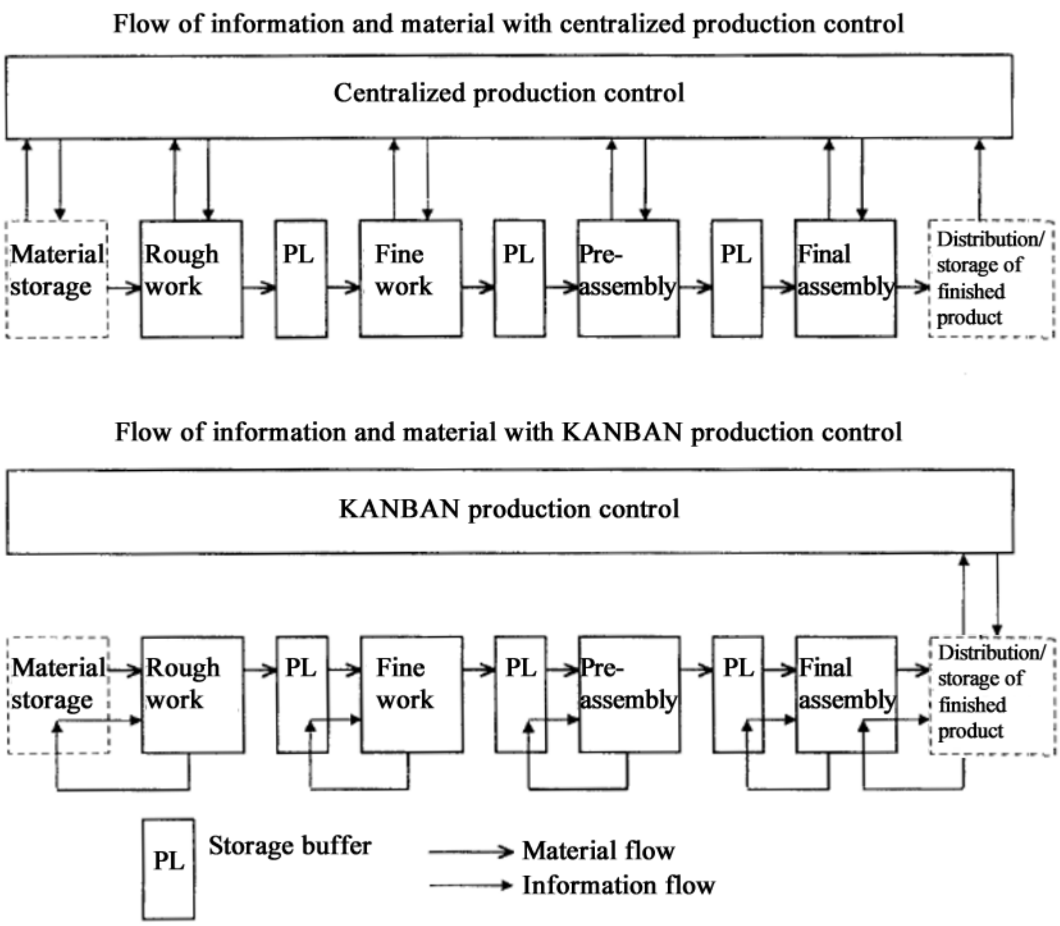


Figure 16: Comparison between the flow of information and material with classical production control and with KANBAN production control

Our vantage point is the last used step in the production chain.

If this principle is to function, a few rules must be followed. Firstly, the consumer can never request more material than is necessary, but he must place his order sufficiently in advance. The producer can never produce more than was requested while strictly maintaining the required level of quality. The internal production control should aim to evenly distribute the production load across the production areas.

AX, BX, AY and BY parts are considered KANBAN worthy. By way of example, the production requirements are mass production, consistent required quantities or a simple production structure with only a few production steps.

These are some of the advantages that KANBAN has:

- Reduction of inventory levels
- Reduction of production times
- Reduction of interim storage requirements
- Responsible workers
- Transparency

The production processes (various possibilities for the organizational design of the production procedure due to the factory layout, distribution of operating resources and workspaces into production units) is divided into two areas:

Types of production and manufacturing:

Products are manufactured simultaneously or immediately after one another in individual, series, batch, lot, mass or coupled production. An important criterion is the level of repetition in the manufacturing process.

- **Individual production**
  Every product is individually produced or is produced just once (e.g. special machinery, steel frames, special devices, etc.).

- **Series production**
  A limited number of identical products such as consumer or capital goods are produced. A characteristic of series production is the amount of repetition. This type of production is divided into large and small variants.

- **Batch production**
  Variations of the same type of product are manufactured one after one another (e.g. screws). The variants usually differ in terms of size and quality but the production process and the operating materials remain the same.

- **Lot production**
  This is a special form of batch production that has slight variations in the production process for each product resulting in different levels of quality and finishing for products such as distillates,

tiles, paints, molten metals and medications. This type of manufacturing is considered to be process-related production.

- **Mass production**
  Large numbers of the same standardized product (e.g. cement, screws) are manufactured over a given period of time. This production is aimed at the "anonymous market" which usually means that it is used to replenish warehouse stocks.

- **Coupled production**
  Coupled production (connected products) is used to produce various end products out of the same base material (often used in oil refineries and sugar factories). Alongside the main product, other marketable products are also produced.

Types of organization:

The location of the operating materials and workplaces are determined by the manufacturing sequence. Production can be separated into workshops, lines, assembly lines, islands and flexible production units.

- **Workshop production**
  Operating materials and related work stations are combined into a single production unit (e.g. foundry, mill, blanking shop, assembly shop). The component parts are transported to the individual workshops during the manufacturing process and the material flow is based on the job shop principle.

  Workshop production is appropriate for individual and small series production because the flexibility of production is required.

- **Group production**
  Group production is carried out in workshops but every task is performed on the same object by a working group. The operating materials are organized according to the flow principle.

  Group production is used for individual and series production. The transport distance of the component parts is shorter than in workshop production and the production time is shorter as well.

- **Line production**
  Line production is a special form of batch production where the required operating resources and workplaces are situated and ordered according to the work that must be performed on the component parts.

  As opposed to assembly line production, the working steps are not synchronized which means there are no fixed time constraints per step. There are buffers of varying sizes between the individual workstations.

  Line production is used for series and mass production.

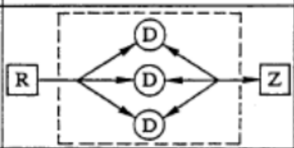
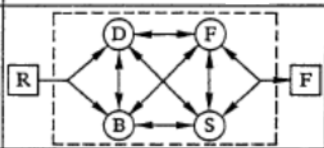
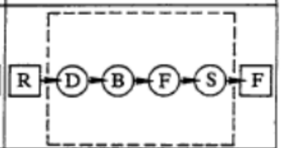
- **Assembly-line production**
  Assembly line production is production where each step must be completed within a certain amount of time. The passage of the components through the individual workstations is designed so that there is no process related waiting time between stations thus greatly reducing the production time. The timing constraints between two consecutive workstations can be alleviated in some cases using buffers. An integral component of assembly line production is conveyor transport.

  Assembly-line production is used for large series and mass production.

- **Island production**
  This production concept allows for adjustments to be made to small market changes or intra-company necessities. Independent work groups work on one product or component (to completion as far as possible) without having to leave the island. The required operating material is available to every group.

- **Flexible production**
  Flexible production systems consist of multiple individual machines at various manufacturing processing stations that are connected with each other via a common information and material flow system. It is possible to work on various products in small or medium sized quantities at the same time or consecutively.

  Furthermore, flexible production cells, flexible production systems and flexible transfer lines are subcategories within this type of system.

		Production principles		
		Workshop production	Group production	Assembly-line production
Design concept				
Parameters	Area of responsibility	Workshop area	Production group	Production line
	Type of processing	Identical	Variable	Variable
	Processing sequence	Arbitrary	Grouped	In a row
	Material flow	Variable	Variable	Prepared
	Scope of work	Partial processing	Total processing	Total processing
	Design foundation	Process	Component and process	Component
Processing possibilities	Component dimensions	Various component dimensions	Similar dimension	The same or similar dimensions
	Same technology	Same technology	Various technologies in various orders	Various technologies in the same order

Legend: (D) ≙ Turning, (F) ≙ Milling, (B) ≙ Drilling, (S) ≙ Grinding, - - - - - System boundary, [R] ≙ Raw part storage, [Z] ≙ Intermediate storage, [F] ≙ Finished part storage, ——→ Material flow

Figure 17: Characteristics of various production principles

1.2.4 Effects of waiting and idling on production times

A production program sets out establish the guidelines for intended production according to quantity and delivery date. The production program planning time period can range from days to a period of months (short, middle and long term).

Throughput time is an important element of job scheduling. It represents the period of time required to complete a component or contract beginning at the start of its manufacture and ending upon its completion and delivery to the sales area.

Some causes for long throughput times can be:

- Missing or incorrect parts
  Long machine set-up times
  Incorrect capacity calibration

The throughput time can be illustrated as follows:

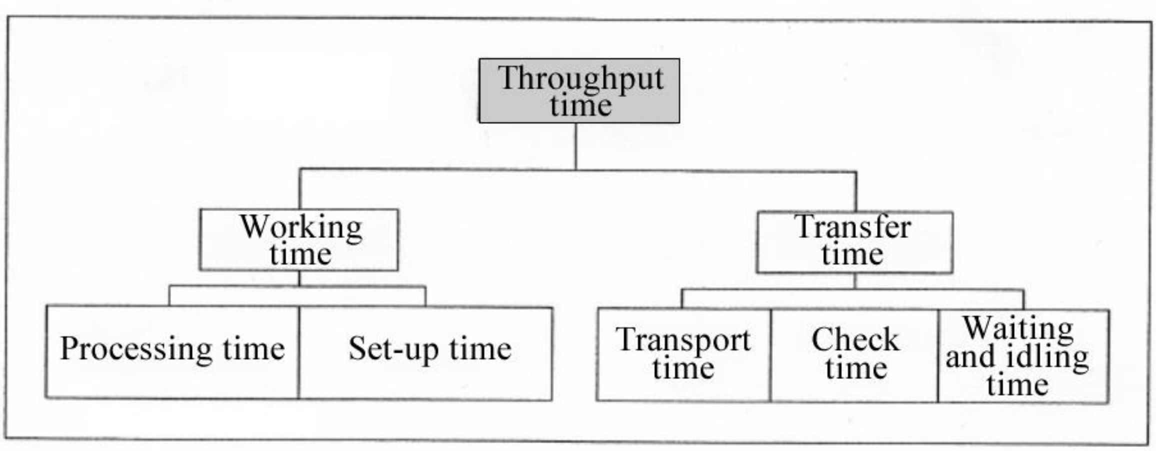


Figure 18: Breakdown of throughput time

“Idle time results from

- The impossibility of exact scheduling
- The effects of short-term disruptive influences
- The requirement of working buffers for production and transport to avoid waiting times

Idle times in German companies are a serious issue as shown by studies that have determined that component idle times can account for up to 85 percent of the total throughput time. In his book “Industrielle Produktionswirtschaft”, Kern points out the example of the production of a men’s shirt which only has a real manufacturing time of 25 to 30 minutes but has a total throughput time of 20 days. A complicating factor is that, as opposed to actual production times which can be highly optimized in work planning, often only estimations of idle times are entered in scheduling plans. Additionally, the idle/wait times can be distributed among the component storage time, process-related idle time, disruption-related idle time as well as human-related idle time.” [Schmitz, P. 11]

1.3 Logistics of distribution and disposal

The goal of **distribution logistics** is the "desired delivery of goods and services to customers while minimizing the costs for the storage of finished parts, packaging, marketing, service and transport." [Sommerer, P. 33]

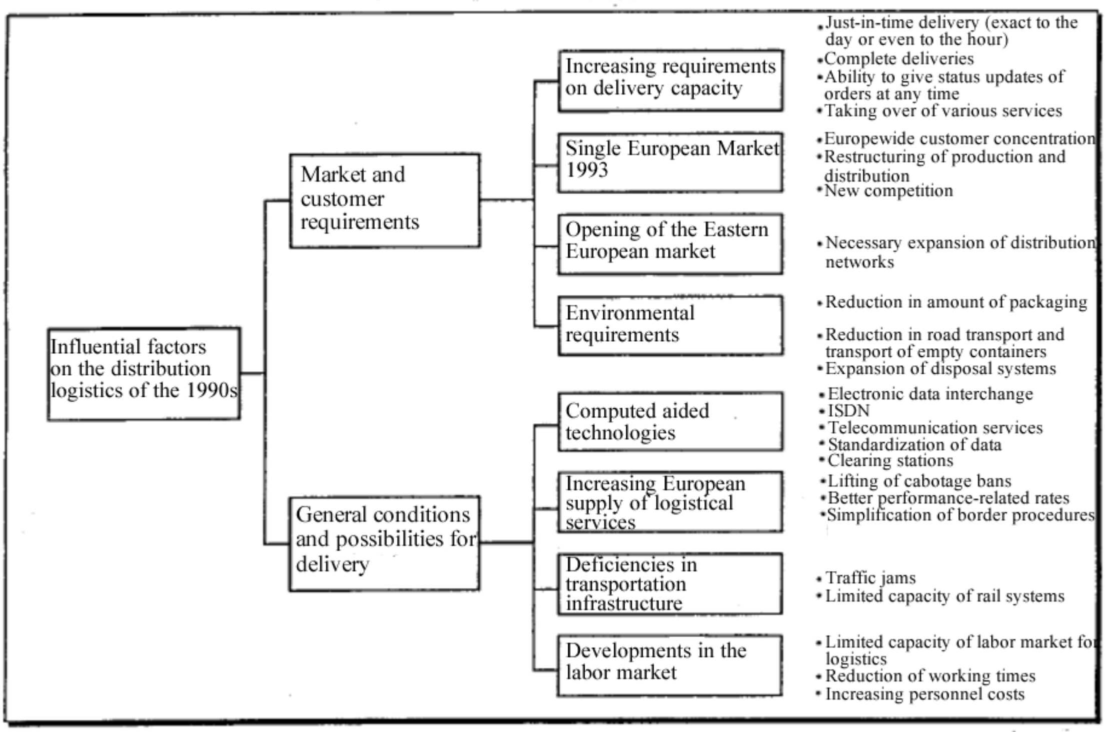


Figure 19: Influential factors on distribution logistics

1.3.1 Distribution methods

The choice of distribution method and the manner in which products are distributed between storage and customers is to be handled by the distribution logistics department. The goods are fed to the end user via a network of transport systems, storage and packaging stations although logistic services, institutionalized trade organizations and various transportation systems can also be used." [Heiserich, P. 190]

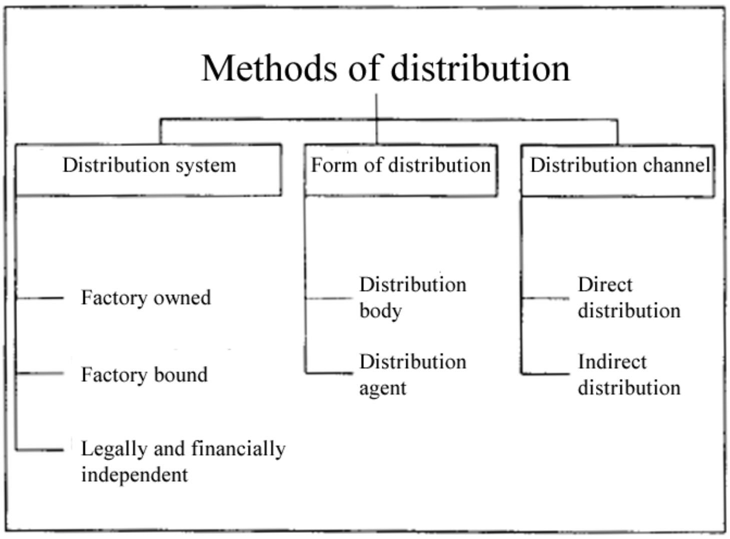


Figure 20: Methods of distribution

The manner in which the goods are to be delivered from the producer to the customer must already be decided during production.

In determining the distribution channel, a decision must be made as to whether to employ direct or indirect distribution.

- **Direct distribution** (company-owned system) is handled by travel, sales subsidiaries or franchises.
- **Indirect distribution** (external system) is handled by sales representatives, agents, wholesalers or retail businesses.

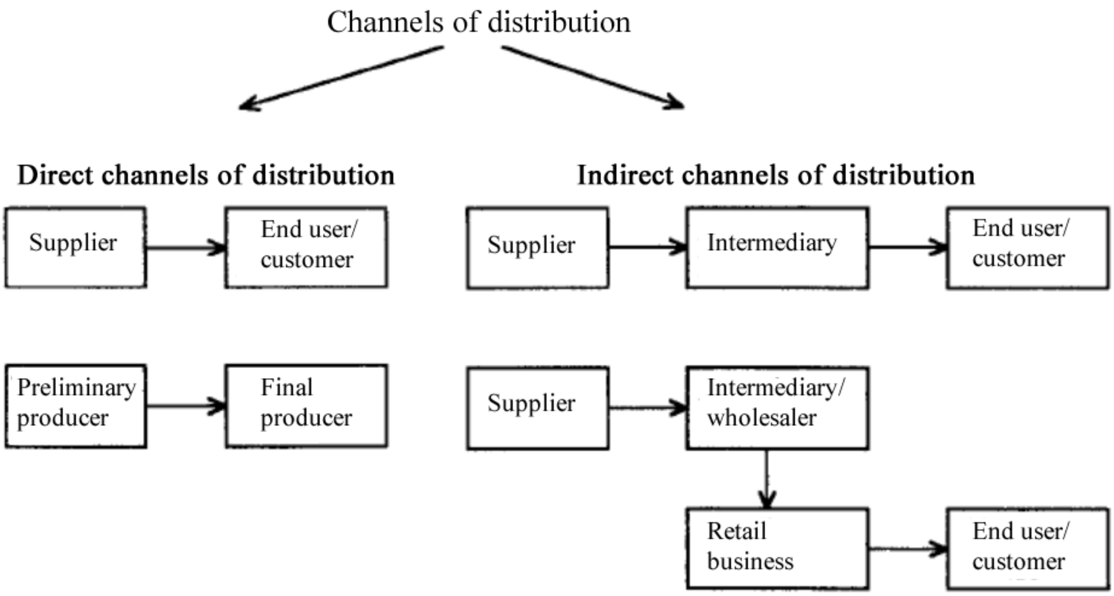


Figure 21: Direct and indirect distribution channels

Sommerer divides the direct distribution channels into three types of businesses: direct business, third-party business and brokerage business.

In **Direct business**, the goods flow directly from the manufacturer to the customer with various types of transport. Payment is also made directly.

There is a distribution or logistics center between the supplier and the customer in **third-party business**. Processing is handled by these intermediaries and the goods flow directly from the manufacturer to the customer.

The term "brokerage" means that an agent or go-between who deals with both the supplier and the customer is used. The formation of the contract, the flow of goods and payment take places directly between the supplier and the customer.

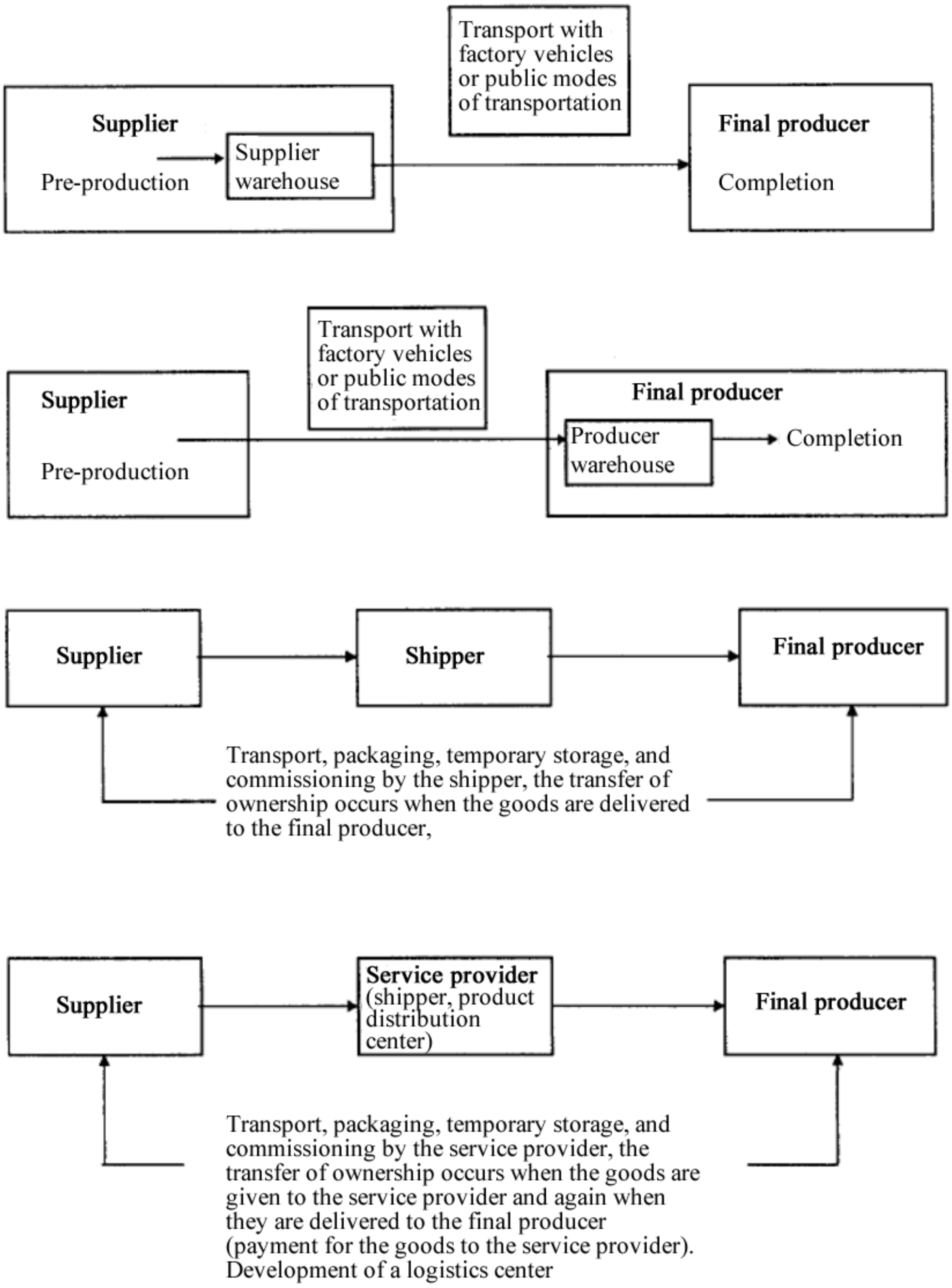


Figure 22: Illustration of the principle of the integration of service providers into the flow of goods.

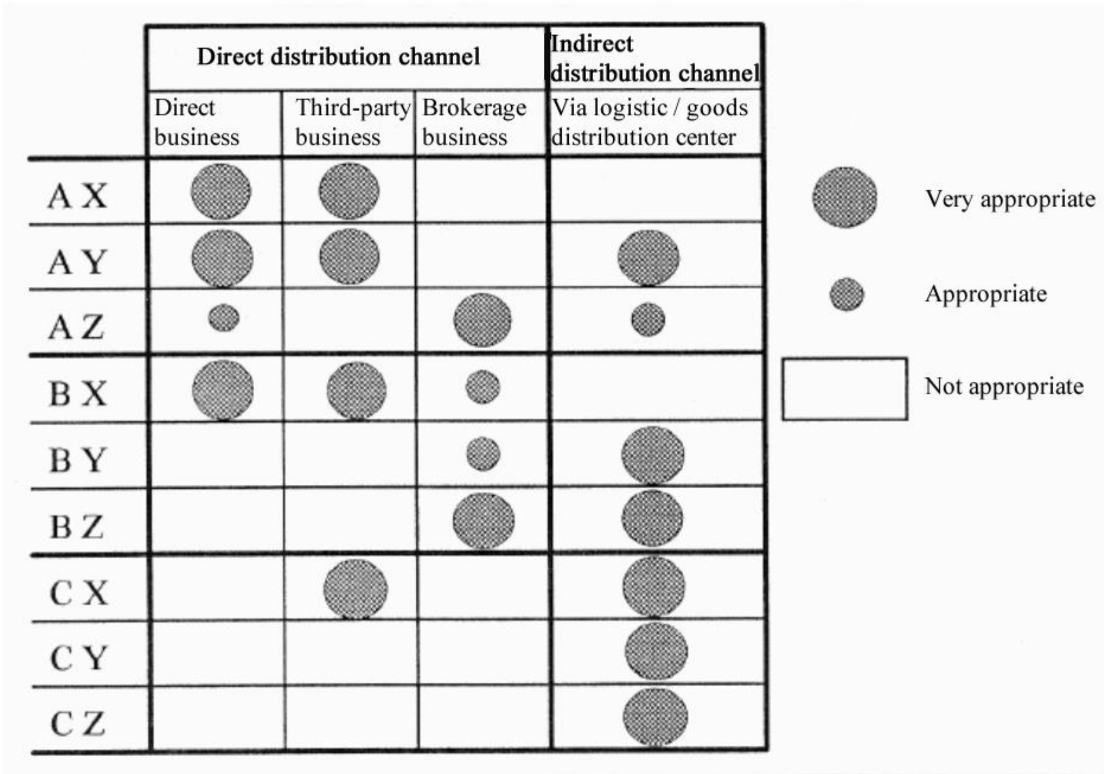


Figure 23: Classification matrix of ABC/XYZ parts and distribution channels

The selection of the right **modes of transportation** for external transport is influenced by a variety of criteria: Speed, reliability and security of the transport, amount transported per time unit, transport price, potential transhipping and many other factory as well.

The following overview can be used to help select the optimal mode of freight transportation:

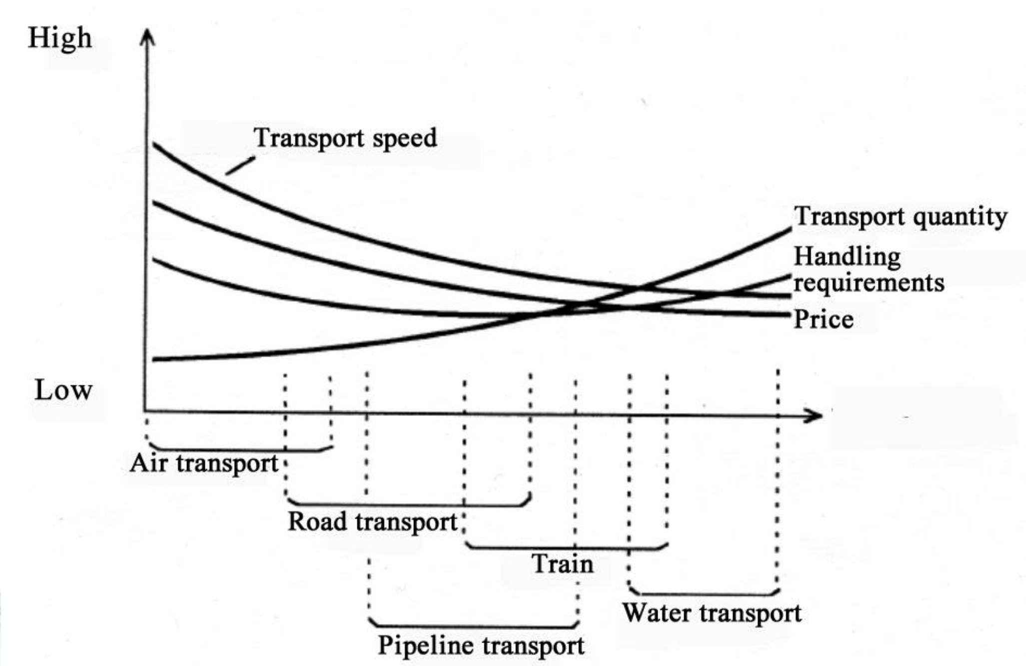


Figure 24: Illustration of the working areas of various modes of shipping

The following table illustrates the advantages and disadvantages of various modes of shipping:

Type of shipping	Advantages	Disadvantage
Rail transport	- Higher weight capacity than a truck - Exact time tables - Largely free of disruptions - Approved for shipping hazardous materials - Low environmental impact	- Private rail networks/railway siding or the use of the use of rail liners - Additional costs when rented specialized cars - Good packaging is required
Road haulage	- Time and cost savings in local or surface traffic - Time saving for long-distance shipping - Flexible routes and time tables - Suitable for specific freight - Flexible delivery times	- No exact time tables - Dependent on weather - Can be negatively affected by traffic conditions - Limited load capacity - Some hazardous materials can not be transported - Environmental considerations
Parcel services	- There are low-cost private parcel services than the postal service	- Private parcel services have no contractual obligations and service is limited to main traffic areas
Air transport	- High shipping speed - No need for waterproof packaging	- High shipping costs - Handling at airports is rather time intensive - Limited weights and sizes of goods - Environmental impact
Barge transport	- High individual weight capacity - Large loading areas - Availability of specialty ships - Low shipping costs	- Limited transport network - Without your won loading area, higher costs are incurred due to subdivided transport - Dependent on water level as well as ice and fog
Sea transport	- High individual weight capacity - Large loading areas - Availability of specialty ships - It is possible to ship valuable goods by using containers	- Limited to ocean ports - Dependent on weather as well as ice and fog - Limited to standard routes unless a ship is specially chartered - Goods are subjected to stress while at sea
Pipelines	- Offers continuous flow of gasses, liquids and solids (as floating goods) - High reliability - Environmentally friendly	- High investment costs limit viability to long-term applications
Combined transport	- Uses the specific advantages of a particular form of transport in the transport chain	- Investment in time due to the transfer of goods - Reliance on routes and time tables - Waiting times at transfer stations

Figure 25: Advantages and disadvantages of various forms of transportation

1.3.2 Data processing and telecommunications

The use of highly modern data processing and telecommunication systems is necessary in all areas of logistics. They are used to keep inventories to a minimum, to reduce throughput times, to keep delivery schedules and to maintain optimal costs during production.

> "Low inventory levels, time-critical deliveries and a multitude of potential disruptions in external logistical processes require a large exchange of shipping and transportation data so that shippers, service providers and receivers can base their decisions and operations on current status information. It is necessary to receive the current status of the flow of goods along the entire logistical chain as well as the progress of shipments on their way to their recipients so that they can be tracked. It is possible to link suppliers, receivers and service providers into one integrated organizational and informational system. This would consist of connecting the production and control systems of the supplier, assembler and customer with the shipping service's data acquisition system. This self-contained flow of information will improve and speed up the flow of information to the involved companies and thus increase the flexibility of the process and the planning reliability (even in operational areas) while reducing the amount of administrative work." [Heiserich, P. 237]

The following diagram shows the optimal data acquisition system.

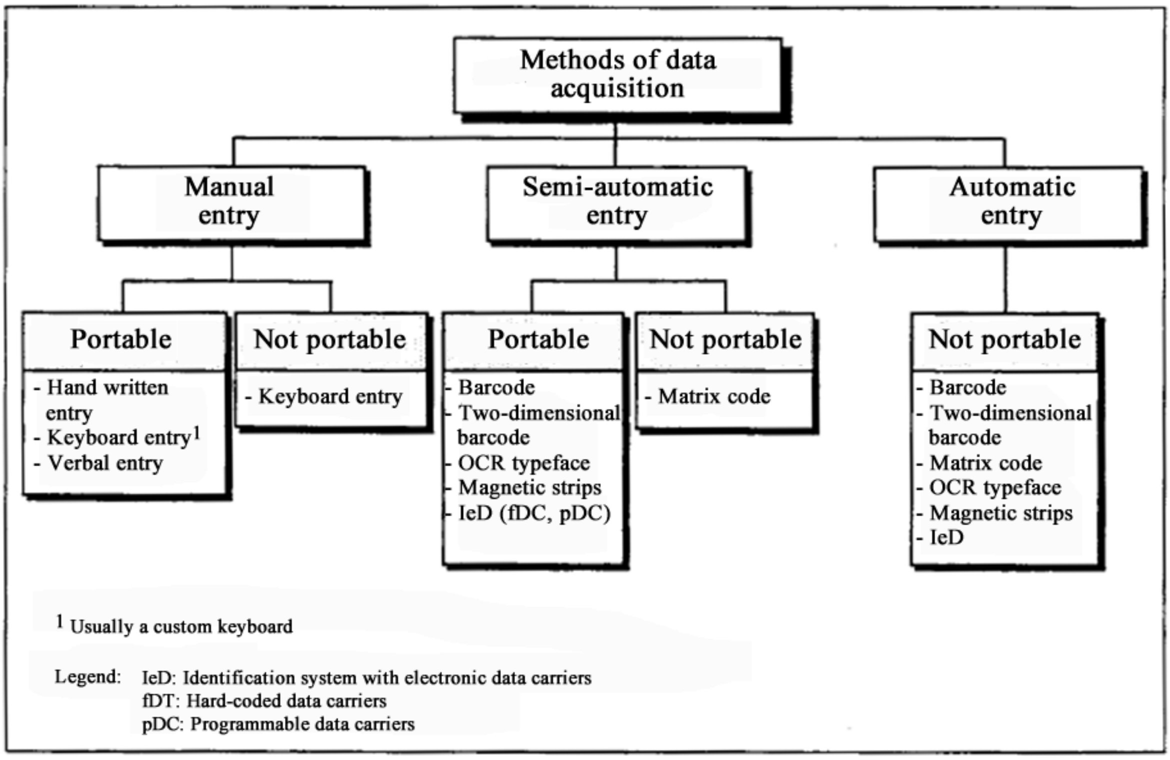


Figure 26: Methods of data acquisition

Methods of data acquisition are divided into online and offline methods.

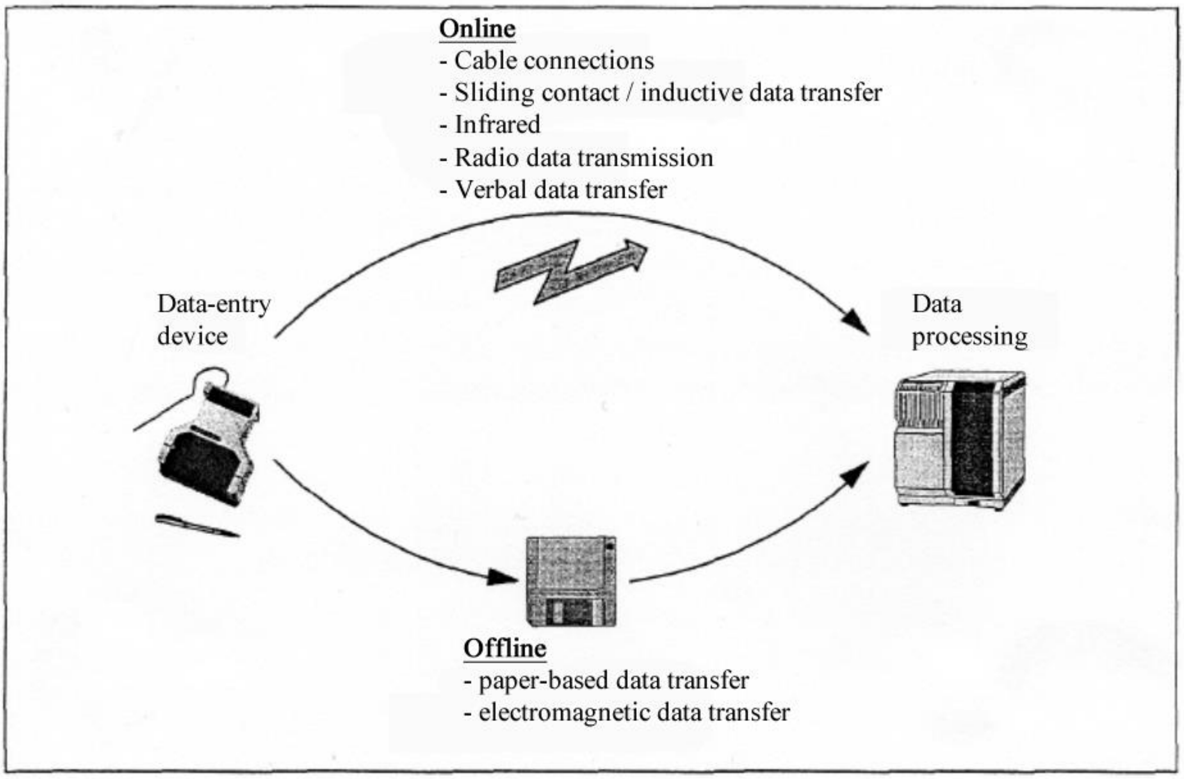
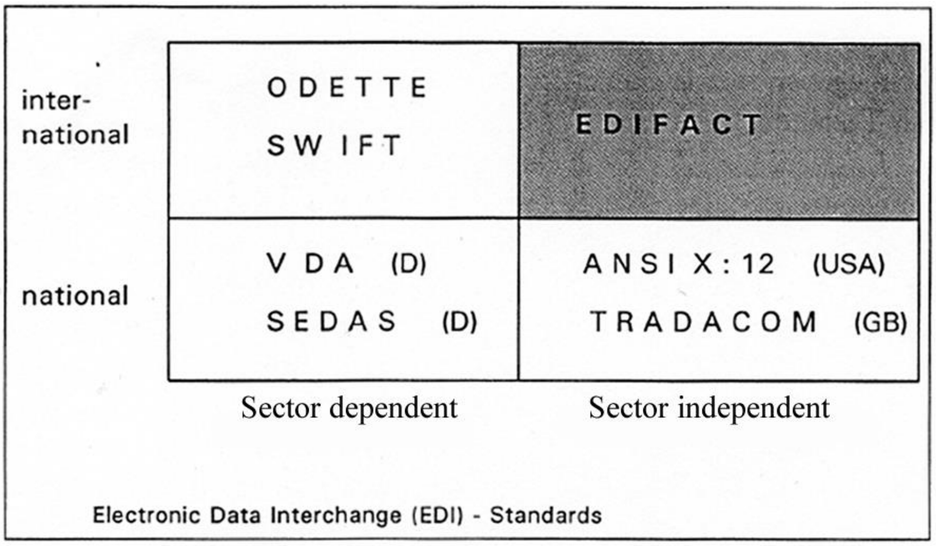


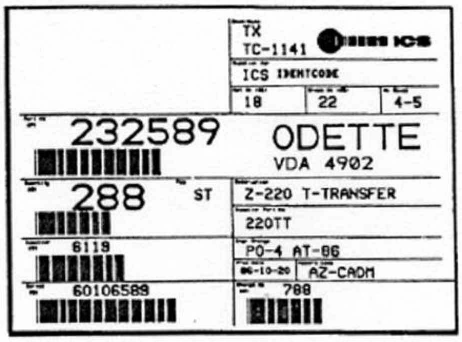
Figure 27: Data transfer methods

The next diagram illustrated the variety of data-exchange systems in national and international data processing.



Examples:

EDI:	Electronic Data Interchange
EDIFACT:	Electronic Data Interchange for Administration, Commerce and transport
EDIFICE:	Electronic Data Interchange for the Electronics Industry
CEFICE:	Electronic Data Interchange for the Chemical Industry
VDA:	Electronic Data Interchange for the German Automobile Industry
ODETTE:	Organization for Data Exchange by Teletransmission in Europe
TRADACOM:	Trading Data-Communication Standard
SWIFT:	Society of Worldwide Interbank Financial Telecommunications
SEDAS:	Standardregelungen einheitlicher Datenaustauschsysteme (Standard regulations for standardized data exchange systems.



VDA/ODETTE standard label

Figure 28: Standards of electronic data interchange (EDI)

The **elecktronische Datenaustausch (electronic data interchange) (EDI)** has been in use for decades. EDIFACT is a worldwide standard for the representation of business and trade data for electronic data exchange between companies and business sectors. The UN/EDIFACT standard is increasingly used for international processes. The advantages of these standards are found in the rationalization of working procedures, faster information flow, reduction of inventory levels and the resulting reduction in capital investment and the optimal design of the logistical chain among other things.

1.3.3 Logistics of disposal

The goal of disposal logistics is the "economical and environmentally responsible disposal of production and packaging waste from the production and operating areas as well as the disposal of customers' old products by increasing the speed of the flow of materials to recycling stations and landfills." [Sommerer, P. 34]

The integration of disposal logistics into the companywide logistical chain is illustrated in the following diagram.

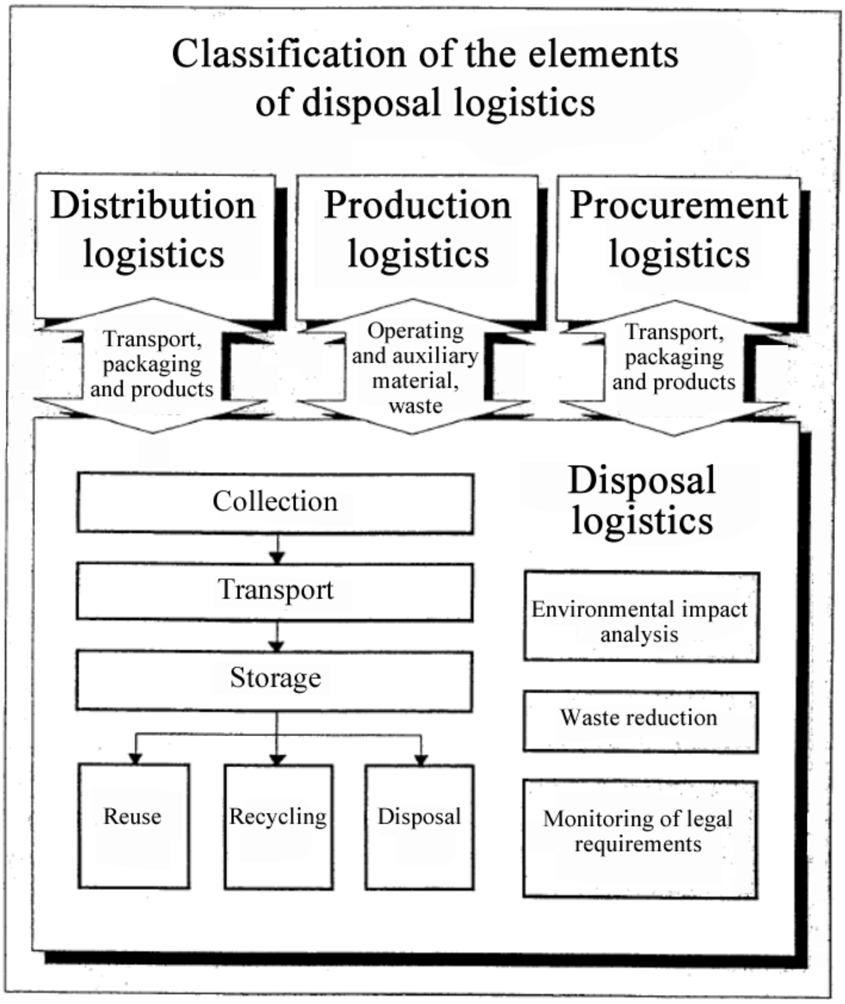


Figure 29: Classification of the elements of disposal logistics

There are plenty of factors that impact disposal logistics.

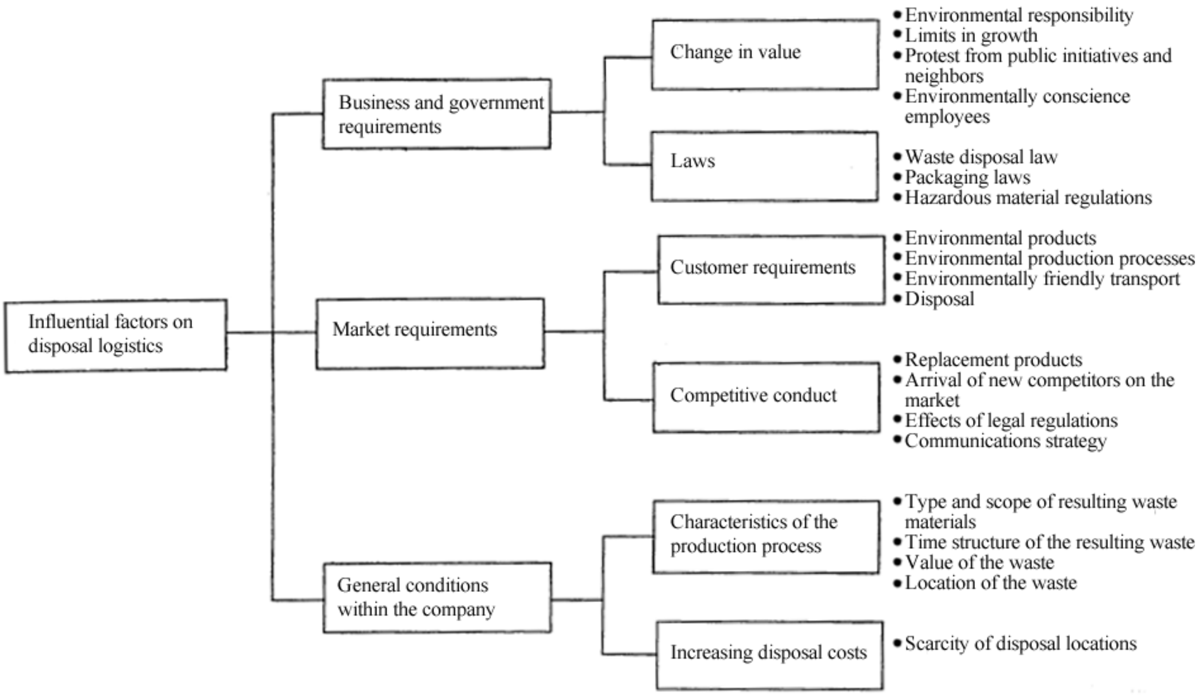


Figure 30: Influential factors on disposal logistics

The above-mentioned influential factors also influence the types of disposal processes.

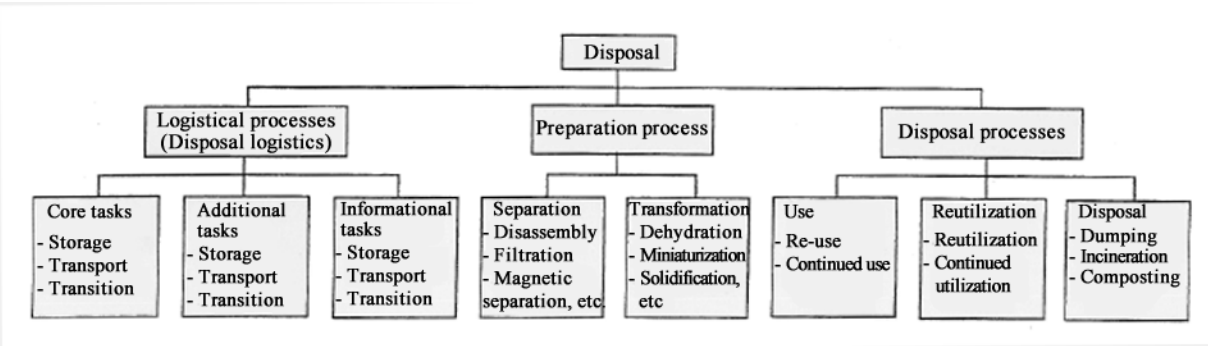
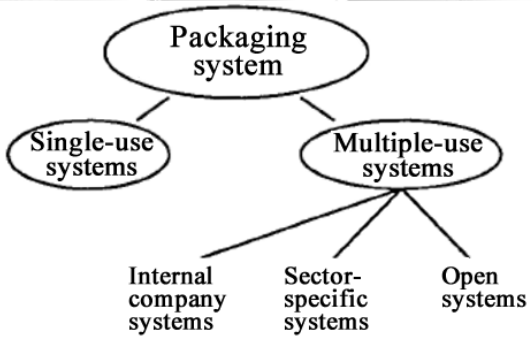


Figure 31: Types of disposal

The previously mentioned criteria affect the packaging systems.

Packaging systems



Balance of arguments

	Single-use systems	Single-use systems
Advantages	- Low production costs - Low weight - No cleaning - Simple distribution - Individual design	- Reutilization - Limited individuality (Market articles) - Compatibility with law - Pooling
Disadvantages	- Environmental impact - Encourages a disposable culture - Puts a load on landfills - Decreasing acceptance	- Capital commitment - Return, repair, administration and cleaning costs - (Possible) adverse module creation

Basic promises

- Standard packaging is preferable to individualized packaging
- Multiple-use systems are preferable to single-use systems
- Materials must be environmentally friendly or recyclable
- Technical transport and storage requirements must be able to be met
- Total cost calculation results in economical solutions

Figure 32: Packaging system

2. CORPORATE LOGISTICS

Corporate logistics concerns itself with finding optimal combination of people, technology, control systems and information. The task of corporate logistics is to economically plan, design, check and control the flow of materials, goods, production and information from the supplier to the company, within the company itself and from the company to the customer.

This means that the scope of responsibility of corporate logistics extends beyond the boundaries of the company itself. This cross-system consideration of the flow of materials and information can yield synergistic effects.

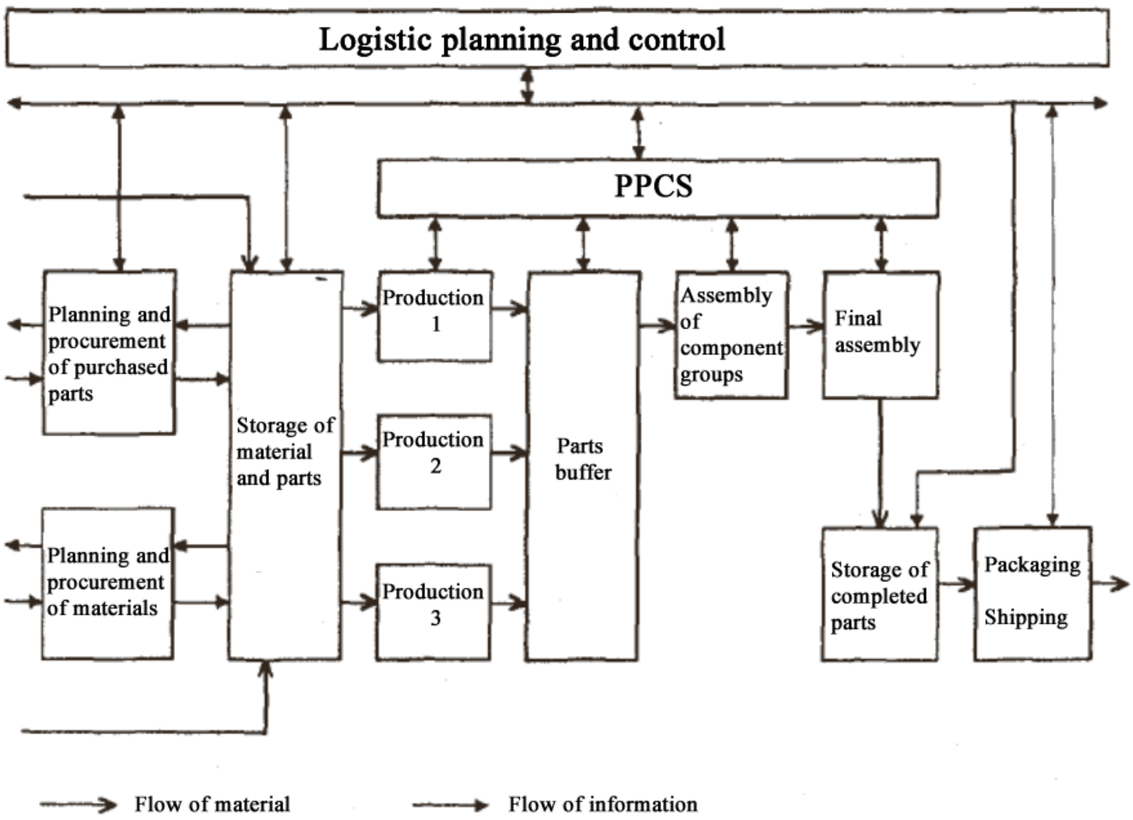


Figure 33: Scope of responsibility of corporate logistics

2.1 Logistical areas of operation in a company

Based on the general definition of “logistics”, specific and valid definitions of the concept can be derived by considering the individual operating areas. The following diagram illustrates the individual operating areas.

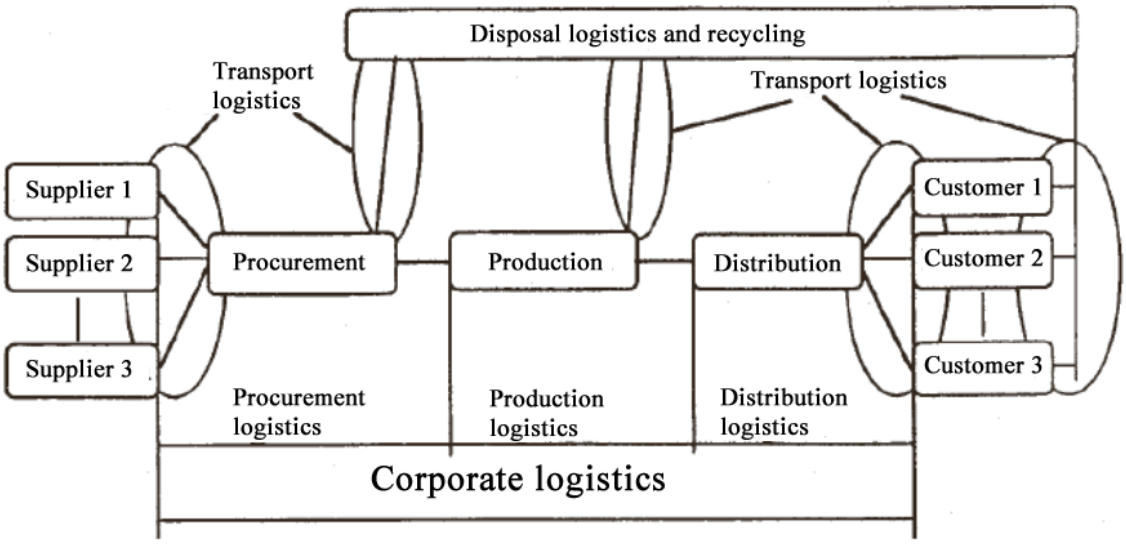


Figure 34: Illustration of the principles of the operating areas of corporate logistics

Procurement logistics refers to the complex planning, control and physical handling of the flow of materials and purchased parts from the suppliers to the production department and includes the necessary flow of information with the goal of accelerating the material flow while minimizing the costs incurred during the procurement process.

Production logistics refers to the complex planning and control of the production process, internal company transport, packaging and intermediate storage processes and includes the necessary information processes with the goal of accelerating the material flow while minimizing the costs incurred during the production process.

Distribution/outbound logistics refers to the complex planning, control and physical handling of the flow of finished products starting at the acceptance of the goods from the production department or from suppliers up until the goods are transferred to the end user or customer. This includes the necessary flow of information with the goal of accelerating the material flow while minimizing the costs incurred during the distribution process.

Disposal logistics refers to the complex planning, control and physical handling of the flow of production waste and old products from its point of origin to its environmentally friendly disposal or the recycling of these materials. This includes the necessary flow of information with the goal of accelerating the material flow while minimizing the costs incurred during the disposal process.

Transport logistics refers to the complex planning, control and implementation of the transport of materials, parts, products, supplies and waste and includes the necessary flow of information while taking all of the means of transportation into account with the goal of minimizing the transport volume as well as the minimizing of the costs incurred during the complete transport process while increasing the speed of the flow of materials.

The required operating areas depend on the **type of company** in question:

- For a production plant
  Procurement, production and distribution logistics
- For a commercial business
  Procurement and distribution logistics
- For a service business
  Distribution logistics

The fields of disposal, transport and storage logistics may also need to be considered depending on the operational requirements. These could be additional separate areas of operation or they could be integrated into the other fields.

2.2 Logistical control loops

There are a variety of control loops which can be used for company related logistical control to achieve the goal of fulfilling customer requests or orders. If a job can be completed using the current production program or even using existing inventory, then product development and technical preparation will not need to be carried out. For cases in which there are specific customer requirements or when a new product is to be manufactured, then these departments must get involved.

This results in two logistical control loops:

- **Tight control loops** which involve the logistical operating areas of procurement, production, distribution including the corresponding integrated storage and transport logistics system.

- **Expanded control loops** in which the additional operating areas of product development and technical preparation are used as well.

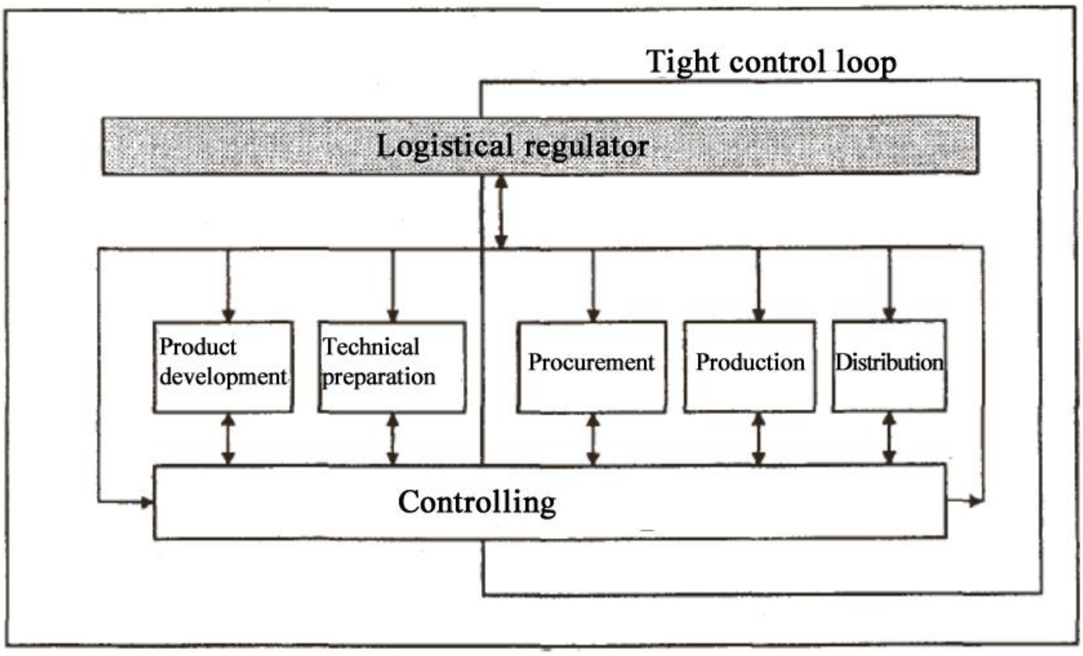


Figure 35: Illustration of tight and expanded control loops

2.3 Logistics in the company structure

The implementation of a logistical area often means that a company will have to be restructured. The degree in which the organizational structure can or should be changed is heavily influenced by internal and external forces such as the size of the company, the previous company structure, market requirements and the company's financial situation. The new logistics department can be centralized or decentralized depending on the new or previously existing company structure.

A centralized system means that the logistical tasks are integrated into an existing department such as:

- Inventory control, procurement
- Production control, program planning
- Support of storage technology and transport

Decentralized implementation means that the logistics department is distributed among various operating areas without the existence of centralized coordination and is responsible for the planning, control and physical handling of logistical tasks.

Figure 36 illustrates a functional organization as the simplest design of a company structure. Creating a logistical department results in easier coordination and the production processes being better suited for the requirements of the market. An increase in productivity and a decrease in manufacturing costs can be expected when implementing such a system.

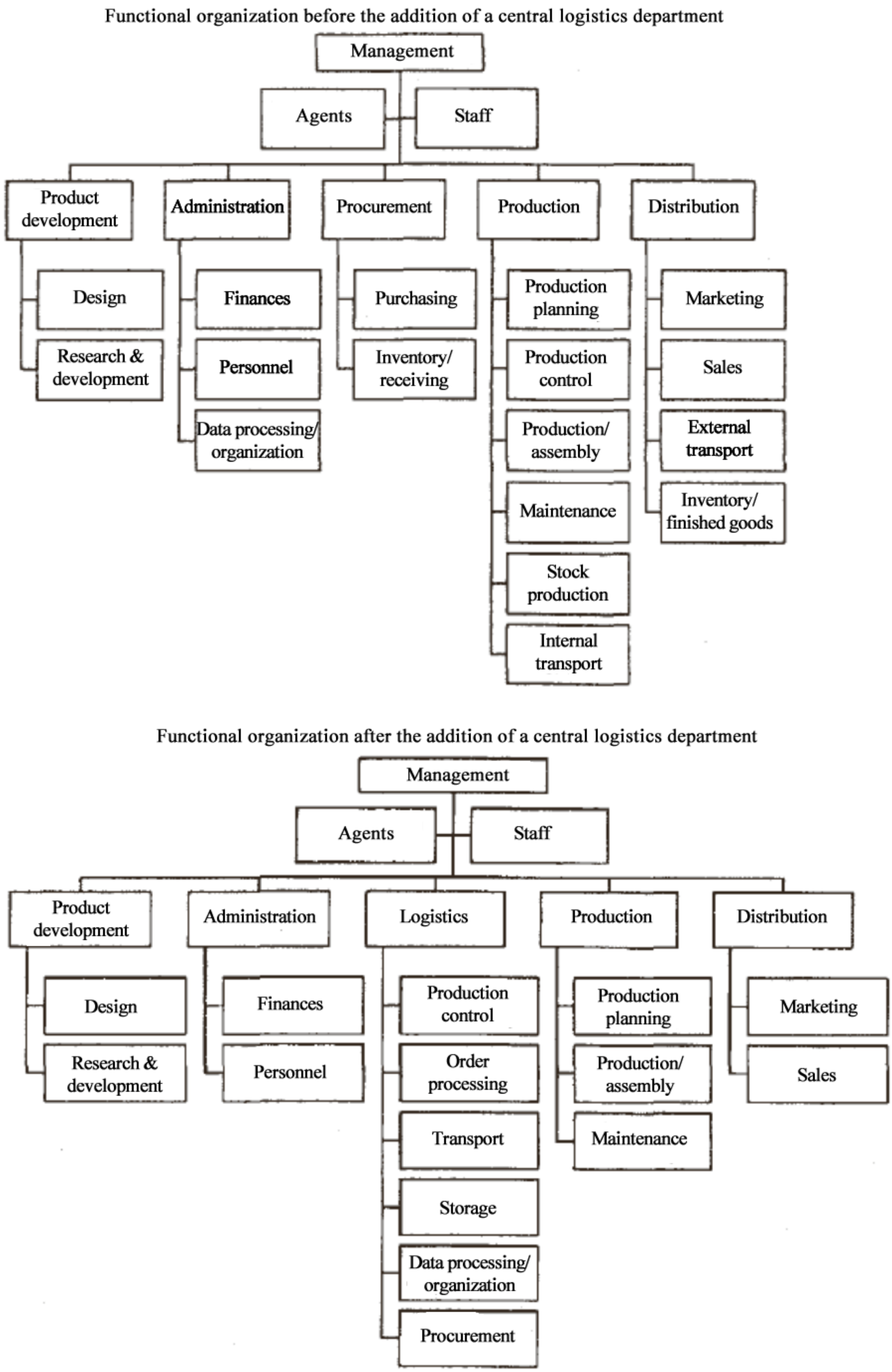


Figure 36: Functional organization

Figure 37 clearly illustrates the difference between centralized and decentralized logistics in **divisional organization**. Centralized logistics has the advantage of coordinated material and information flow in connection with the total optimization of the company structure. A decentralized structure has the advantage of allocating the individual divisions into the profit center.

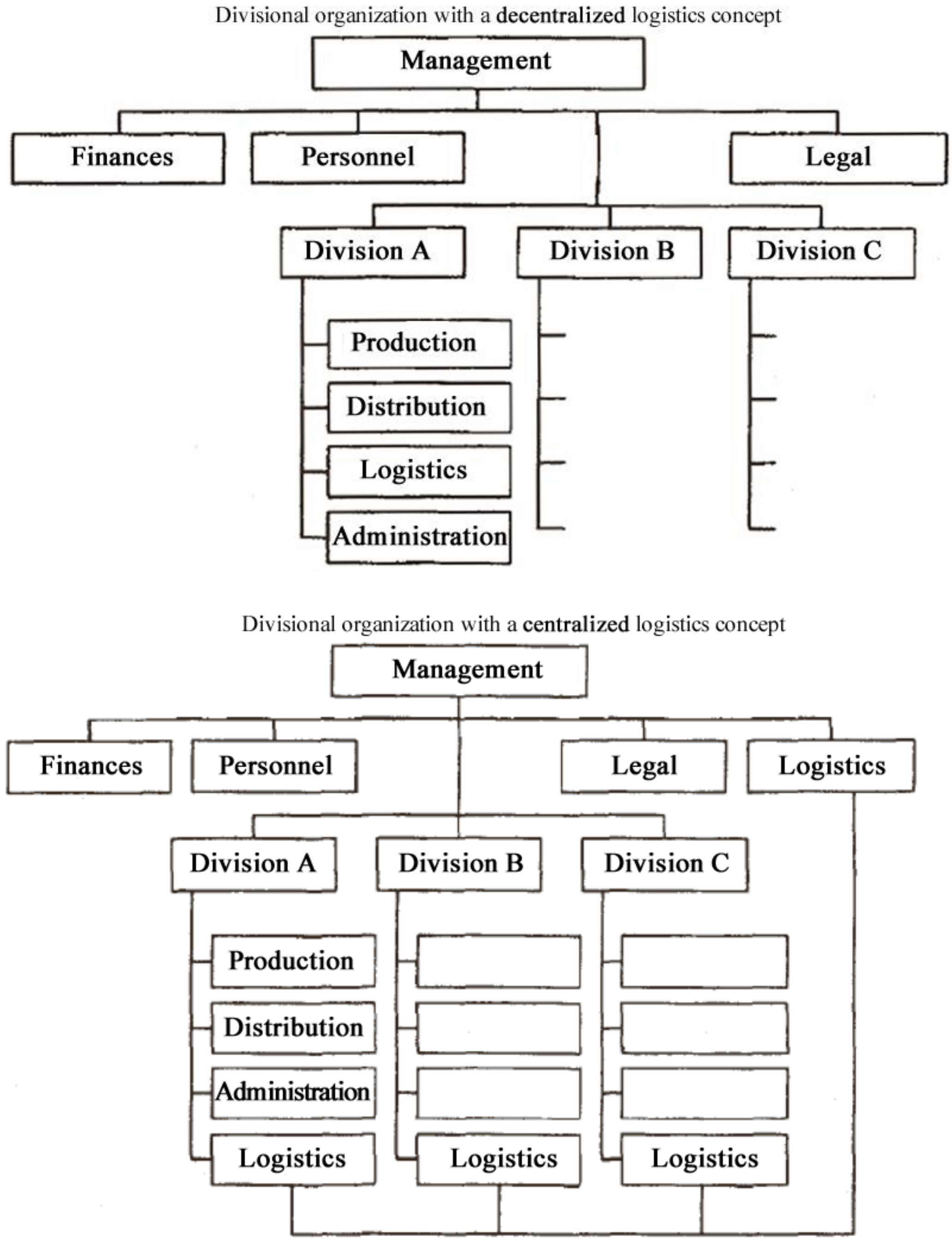


Figure 37: Centralized and decentralized integration of logistical responsibility

3. PROCUREMENT LOGISTICS

3.1 Duties and meaning

The dynamics of the market and its associated individualization of customer requirements and the complexity of the finished products lead to a variety of product variations and thus to enormous growth in the types and quantities of produced goods. This means that the company must increase the amount of materials that must be stored, transported, administered and procured. An individual company will find it difficult to manufacture everything in house due to the high speed of development and the associated costs and must attempt to reduce the variety of parts required to manufacture its goods, despite the fact that more and more varieties of products are being produced. Companies can therefore reduce their in-house production depth, build technology and production oriented production centers and work according to the **modular construction system** or with **component production**. The procurement procedure will become increasingly important and require new organizational structures as well as modified operating methods.

Some things will have to be rethought based on the fact that the success of a company depends on selling its products (with the support of strong marketing and sales strategies) and not on the manner and location in which the products are made.

- A product is released to satisfy market demand. It cannot be released as an end in itself.
- Producing products in house must be justified. Simply using production capacity is not enough of a reason.

A new concept should be implemented to enable costs to be decreased by finding cheaper and faster ways to procure materials. Low individual costs for parts and component groups as well as low inventory levels ensure a low capital commitment despite the increase in product variety that the market demands. In order to reduce the cost-intensive coordination and procurement processes that must be carried out with the suppliers, a shift from comprehensive part production to the manufacture of modules and components would make sense. Such considerations result in the trend of increasing amounts of procurement which leads to procurement logistics increasing in importance. Procurement logistics must answer to a variety of company areas and is confronted with varying corresponding requirements:

- Production requires high quality materials/goods and the timely fulfillment of any requirement.
- The distribution department and the warehouse require rapid procurement of trade goods in small lots and consistently sufficient inventory levels.
- The purchasing department (this can be a component of procurement logistics) prefers to place large orders with sufficient delivery times to receive better order conditions.
- Management and financials department require low inventory levels because of high storage costs and capital commitments.

This means that the task of procurement logistics is to optimize the flow of materials, goods and information between the supplier, the company and the individual departments within the company through planning, design, control and monitoring. This includes all measures and actions related to the transport and storage of the goods as well as all the requirements regarding the goods' location, status and schedule.

The functions of procurement logistics can be divided into three levels:

- Administrative level
  Includes market research, planning for material requirements and procurement, placing orders, purchasing, material flow planning, administration of storage space, inventory and monitoring.
- Scheduling level
  Includes scheduling of materials, storage and transport, management of the motor pool, storage strategies and inventory management, scheduling and optimization.
- Operational level
  Includes handling, unpacking, transportation, storage, commissioning, staging and monitoring.

The tasks to be carried out can be divided into the following groups for closer consideration:

- Make-or-buy decisions
- Types of cooperation
- Selection of suppliers
- Security of supply
- Cost optimization

3.2 Make or buy

Companies that produce goods are faced with the question as to whether they should produce all the product's parts or component groups on their own or whether it would be economical and/or technically necessary to purchase these parts or component groups. The demand for purchased parts can be satisfied by offers already on the market (e.g. standard parts, semi-finished parts) or by placing orders with suppliers for special production work. These decisions are made individually and are based on a variety of factors. Discussions involving various outlooks regarding the comparison of cost and quality between in-house production and external suppliers are seldom had without any prejudice making its way to the table. These discussions can often lead to questionable solutions. There is no perfect recipe for reaching the decision as to whether to make or buy. Current requirements must be checked and then the "how" must be discussed. The level of cooperation, from simple contract work regarding the purchase of components or finished products to cooperative development, must be determined.

Possible motives and/or requirements for action can result from the following:

- Business start up
- Incorporation of additional business units
- Extension of leases
- Reorganization of production
- Inclusion of new products
- Renovation of operating equipment

- Capacity shortages
- Reduction in operating level
- Changes to the product structure
- Changes in the cost structure of production
- Changes in the cost structure of suppliers
- Changes in the cost structure of the market
- Changes made by suppliers
- Quality or schedule related customer complaints
- Examination of previously made decisions

Criteria for make-or-buy decisions		
	In-house production	**External production**
Willingness to invest	Yes	No
Liquidity Short time/ long term	Sufficient	Not sufficient
Personnel	On hand	Not on hand
Production facilities (available capacity)	On hand	Not on hand
Production space	On hand	Not on hand
Know-how	In-house know-how is on hand. This know-how can only be found in the company. Know-how should be expanded. In-house know-how should not be transferred to others	In the hands of the supplier. Only in the hands of the supplier and protected by patents or licenses
Quality	Supplier cannot provide the required level of quality	In-house production cannot provide the required level of quality
Independence	Would be threatened by external procurement	Would not be threatened by external procurement
Supplier reliability	Not guaranteed	Guaranteed
Company secrets (technical and economic)	Threatened by external procurement	Not threatened by external procurement
Counter dealings	Not desired, not possible	Desired
Schedule	In-house production can meet deadlines and the supplier cannot	Supplier can meet deadlines and in-house production cannot.
Redesigning technical changes	Fast reaction to feedback and strong influence is desired	Simple parts which will not be subjected to changes
Sales quantity (Inventory risk, capacity risk)	Constant	Variable. Fast adjustment is necessary
Production technology	Development of in-house technology	Fast incorporation of the newest production technologies and the use of the cost and technological advantages that they offer
Procurement market	Only a few / no suppliers	Many good suppliers with available capacity

Make-or-buy decisions must be examined regularly as the conditions and requirements constantly change. This can mean the difference between becoming too dependent on a supplier and developing sufficient in-house production capacity.

3.3 Types of cooperation

Types of collaboration	Criteria
Basic agreement (declaration of intent)	The fundamental criteria in deciding on make-or-buy
Guaranty of minimum quantitates (number of pieces, hours). The collaborative work must be in the interest of both parties (only that which works for everyone will succeed!)	The more cooperation there is, the more difficult it is to change suppliers. It is therefore very important to take care in clarifying the following:
Forwarding of the detailed production plan	Possible self-interest of the supplier
Quality control according to in-house requirements carried out by the supplier	Protection of the know-how. The supplier´s existing business relationships
Provision of tools and equipment	The supplier´s future prospects
Provision of operating resources (financing)	
Cooperative development Supplier provided products sold in the company´s own name	
Just-in-time (storage is handled by the supplier)	
Storage of replacement parts is handled by the supplier	
Service is provided by the supplier	
Control of model line	
Paper-free order processing/communication	

Table 38: Types of collaboration

There is a wide spectrum of possibilities for collaboration between **in-house production** and **external procurement**. Production orders can be handed over to a subcontractor who would take care of all of the necessary technical facilities or you could provide your supplier with your own operating resources or finance required investments. There are many types of collaboration that can be both to your benefit and that of the supplier.

There are a few parameters that should be considered in regards to collaboration.

A subcontractor is given the responsibility of handling a portion of production whose scope is predictable and calculable. The main company produces those components that are difficult to predict and calculate for.

A tight collaboration makes it much more difficult to change suppliers. As long as the collaboration benefits and is in the interest of both parties, there should be no reason to question the partnership.

When dealing with **key suppliers**, a high value must be placed on good communication because many problems can be caused by a lack of information on either side. Transparency is very important. It can be very advantageous to share detailed production plans with the supplier so he can plan ahead and can react to your needs faster. In some cases it is worth considering whether the data processing systems of the two companies should be connected with each other.

Zero-error delivery is not only necessary to simplify the inspection of incoming deliveries, but is also important in avoiding buffer stocks. It is therefore very important that there is agreement upon inspection conditions, procedures and equipment as well as trusting collaboration between the corresponding quality management departments.

Adherence to schedules is an important requirement for successful collaboration and mutual transparency fosters this. For a partnership to function well, the supplier must inform the customer of any possible delays immediately and cannot hope or assume that the materials will not be needed on the agreed upon date and time. The customer must likewise immediately inform the supplier if there are any changes in his schedule.

The security of supply is especially important when dealing with supplies of raw materials and energy while the price is a more important factor when dealing with consumer goods.

When there are two possible suppliers, you can quickly balance out any supply difficulties as well as keep the supplier focused on customer satisfaction.

3.4 Supplier selection

Alongside the selection of parts, components and appropriate suppliers, decisions must still be made regarding which suppliers can and should be contracted with long term and which suppliers can and should be given additional responsibilities. In making these decisions, you should consider whether there should be independent or collaborative work in carrying out scientific/technical development of parts or component groups, the later recycling or disposal of goods and the selection of suppliers of raw materials. The decision as to whether or not to work with another company to build up a relationship with possible long-term commitments should be taken very seriously because once a partnership has begun, it can be very difficult to revise or terminate this relationship if you run into problems.

There are many critical criteria that come into play when assessing and selecting suppliers that must be determined and weighed according to their importance. The following criteria should be prioritized:

- Price of the supplied materials or goods
- Security of supply
- Quality of the supplied materials or goods
- Distance from the company
- Possibility for just-in-time commitments
- Intermediate storage and warehousing of the goods
- Flexibility in responding to changing requirements
- Capability of recycling parts or components
- Development and/or further development of the products
- Possibility of linking both companies' computer systems
- Etc.

When deciding which supplier to choose, each possible supplier should be rated in each relevant category on a scale of one to ten. These points should then be added up which will result in a list categorized into A-level, B-level or C-level suppliers.

Storage increases security but also costs money which is why you should try to keep your supply needs satisfied without needing storage. However, if the market requires a delivery schedule that is shorter than your standard production and procurement time, then it will become necessary to find storage for your products. The level of inventory required to bridge this time difference is determined by the corresponding demand forecast and the replacement time. Furthermore, a sudden emergency increase in procurement requirements would surprise your suppliers, leaving them no time to prepare, and could lead to further delays as well as a drop in quality.

It is therefore clear that security of supply can only be ensured within a predetermined, agreed upon framework because the product replacement time has a direct effect on inventory levels and in the interest of maintaining low inventory levels, this part replacement time should be kept as short as possible. Thus, no time can be wasted in administrative or inspection procedures. When there is efficient communication and transparency between the partners, demand forecasts and plans should be made for fixed periods of time. Agreements should be made in advance regarding what measures are to be taken if there are unforeseeable changes in demand so that alterations can be made as quickly as possible to adjust to changing circumstances and thus ensure the security of supply. Arrangements and contingency plans between the partners can include the following subjects:

- Sales program for a defined time period
- The length of time required for reprocurement is defined as the minimum delivery time.
- Acceptable deviations regarding the demand forecast
- Acceptable changes in speed when there are changes in needs
- Levels of reserve inventory for bridging peaks in demand
- Agreements regarding making production more flexible
- Encourage improvements in the product structure

3.5 Optimizing costs

The purchase price represents only a portion of the total cost of procurement. The lowest possible price provided by a new supplier may well be a real key to success for your company. It is also possible, when the company is viewed as a whole, that this supplier change is a mistake bringing grave consequences. There are often costs incurred by such things as supplier maintenance, order processing, intermediate storage, receiving, quality control as well as follow-up costs resulting from initial deliveries and subsequent misdeliveries that are not considered because they can be difficult to anticipate. Cost comparison can often lead to emotional discussions between production departments and procurement logistics or purchasing departments. Optimal solutions require an interdisciplinary approach and cannot be dominated by a focus on price and discounts. This does not only apply to decisions made regarding in-house production vs. third-party production, but also to the selection and comparison of suppliers. When you change to a new supplier, they must first build up the required company know-how and train their workers to meet your requirements. This is why changing suppliers, especially for technically sophisticated components, can be a risky proposition.

The following parameters should be taken into consideration when taking a global view of this issue:

- Quantities agreed upon
- Order processing
- Safe inventory levels
- Production strategies/just in time
- Distribution of transport costs
- Options for transport
- Optimization of material flow
- Quality control costs
- Quantities agreed upon
- Quantities agreed upon
- Quality-related costs
- Inspections by the receiving department
- Purchase price

Two factors are very important when making a cost comparison:

- Level of in-house production utilization

The hourly rate is determined by the production level. If the products under consideration are produced in-house, despite high hourly rates, and the operating resources are spread out over the number of hours of planned production, this has a positive effect on the costs. On the other hand…

- Acquisition cost = manufacturing costs

Additional internal company tasks such as purchasing administration, schedule monitoring, checking received goods, etc. must also be considered.

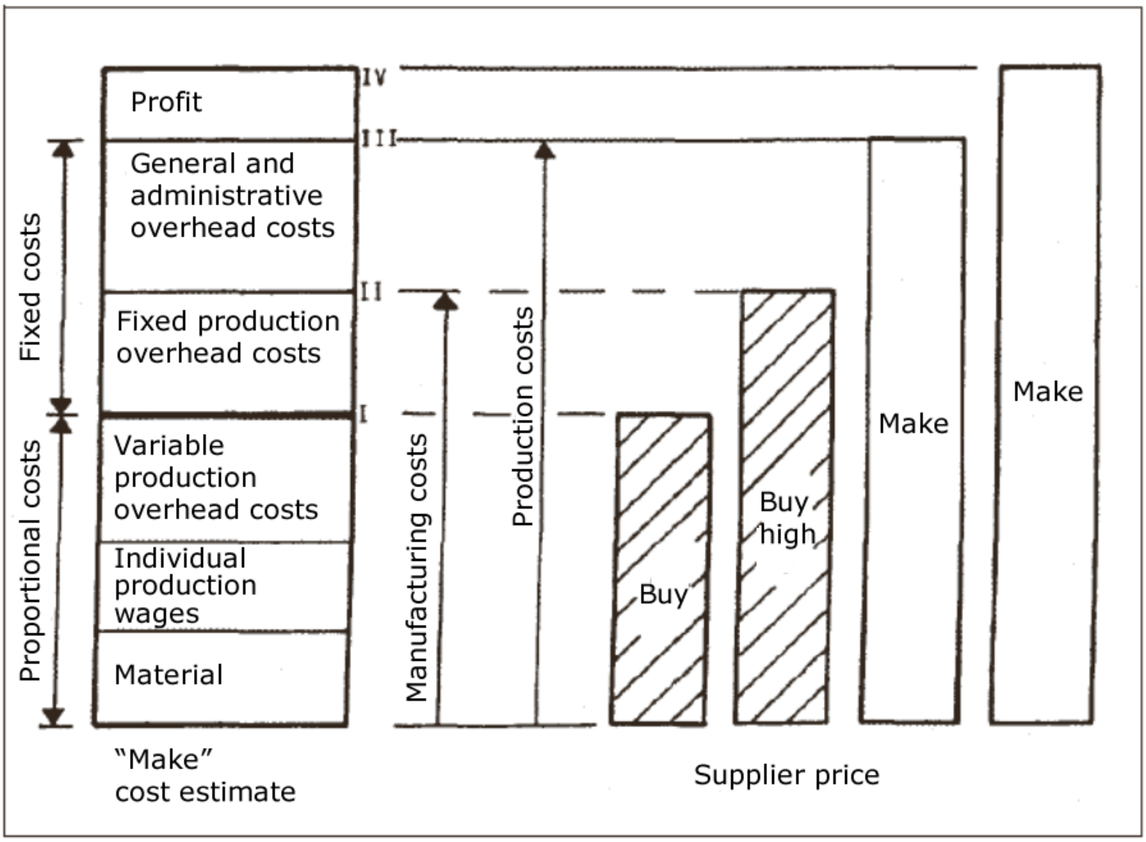


Figure 39: Make-or-buy boundaries

4. PRODUCTION LOGISTICS

4.1 Task and importance

Production logistics is responsible for the on schedule and cost effective provision of the right materials to the right location, at the right time and in the correct quantity. This means that it is responsible for a continuous production flow while minimizing inventories and production costs. The job begins with the provision of the materials to the production stations and includes optimizing and carrying out the transport to and between the production storage areas, the work spaces in manufacturing and assembly areas and the storage area for distribution. The complete flow of information and material is planned, designed, controlled and monitored by production logistics. These functions are divided into three levels:

- Administrative level
  Includes the planning of the production program, capacity planning, administration of storage space and the organization of storage and transportation

- Planning level
  Includes the control of the production and material flows using production planning and control systems according to predetermined storage and transportation strategies.

- Operating level
  Includes manufacturing, assembly, inspection, transport, handling, storage, commissioning, provision and monitoring.

The logistical work of connecting the manufacturing and assembly departments within the company is carried out by using the following:

- Inventories in indispensable storage buffers
- People
- Equipment (vehicles, conveyors, storage technology, transition technology, robots)
- Auxiliary materials (containers, pallets)
- Space and rooms
- Organizational resources (computers, records, information flow)

Logistics looks at the big picture and makes a priority of ensuring the lowest possible inventory levels, low throughput times and adherence to schedules in order to stay in line with market requirements. These factors can lead to difficulties in production such as:

- Difficult capacity utilization due to the decrease in batch sizes
- High job throughput times due to the increasing variety of end products
- Increasing schedule pressure due to fixed deadlines
- Low material inventory with punctual subsequent deliveries
- Absolute adherence to schedules when processing orders
- Fast, flexible adjustment to new situations
- Etc.

The observation and analysis of these difficulties leads to the following findings and considerations:

- The throughput time of orders is too high. The actual work time often represents only 5-10% of the throughput time.
- Storage costs and the associated capital interest can represent up to 20% of the production costs.
- The products must be improved or replaced quickly (lifecycle)
- Information processing no longer needs to be time oriented but instead, action oriented.
- Cycle-oriented production is no longer appropriate for meeting today's requirements.
- Previous PPC systems must be continuously improved to better meet today's needs.

The logistical costs result from the capital commitments in inventory levels and from the costs of the work that the logistics department must do. The determinative factors are:

- Capacity structure of the production areas (degree of coordination among the various production capacities)
- Configuration of the production areas
- Configuration of the buffer and storage
- Logistical capacity structure
- Degree of product complexity
- Production planning and control

Production logistics places special requirements on the design of both production systems and products to minimize the previously discussed difficulties in production, to avoid high logistics costs and to achieve a smooth, fast and cost effective production process.

4.2 Requirements for the production system design

Production must constantly adapt to changing market parameters regarding product requirements (function, quality), delivery capacity, decreasing quantities, increasing varieties of products and so on. In order to meet these challenges, it is essential that the production area be made more flexible to ensure that the complete production structure and supply of materials are capable of reacting to the changing requirements of the sales market. This is achieved by developing and deploying environmentally friendly technologies that save time, ensure quality and minimize costs when carrying out the technical preparation of production design. Some individual examples can be found below:

- Determining the in-house production depth in collaboration with the production planning and design departments with the goal of using technologies that are cost effective and that ensure quality.
- Application of new technologies or advancements with the goal of reducing throughout times.
- Permanent technological harmonization between the individual processes starting when the materials are first staged up to final assembly for the purpose of keeping inventories of finished products low.

When technical units are newly designed or redesigned attention should be paid to not only mechanizing/automating the actual production processes, but also to the auxiliary processes such as conveyance, separation, guidance, removal and so on. This should also include as many surrounding processes as possible like tools, the organization of testing equipment, handling of work and NC programs, etc. These requirements can largely be divided into four basic rules (A-D):

A) The factory structure must ensure good material flow.

   The manufacturing process of a component has many working steps that are often combined into organizational and spatial production areas based on job-shop organization. Bad selection of factory locations can have the negative effects of long distances, doubled transport paths, long throughput times, difficulty in maintaining an overview of production, long reaction times, high material flow costs and difficulties in controlling production. Components must often be transported from one factory to another and then back again. It is therefore very important that a factory structure is planned for that takes the flow of materials into account. An example of such a system would be to have one factory that just handles the manufacture of individual parts and another factory that handles the final assembly of these parts.

B) The layout of machine groups should ensure good material flow.

   The machines and machine groups should be ordered in such a way as to correspond with the flow of the most individual components as possible (the flow principle) or ordered according to what family the parts belong to (the group principle). This will prevent components from having to be transported from one production area to another and then back again. A straight and organized flow of components makes it much easier to maintain an overview of the complete process and also reduces throughput times which allows for much faster reaction times when faced with changing market situations.

C) The capacities of individual machines or machine groups must be calibrated to each other as much as possible.

   The cycle times and the degrees of utilization of the machines should be calibrated to each other. This can help prevent production bottlenecks and long throughput times by minimizing the amount of waiting and idle time of components in the production chain. Further advantages are a better overview of production, less difficulty in tracking the status of jobs and less inventory on the factory floor.

D) Nonproductive time caused by set up, alignment, maintenance, etc. should be reduced as much as possible.

   Changing tools and components, including the necessary inspection procedures, should be sped up as much as possible by mechanization and automation. This will lead to faster equipment and task changes and a higher degree of flexibility in scheduling and quantity which will enable economical production even in small quantities which will make it easier to adapt to changing market conditions. This can be carried out by using CNC machines, machining centers or flexible production systems.

4.3 Requirements of product design

The products must correspond to customer expectations and should be as standardized and recyclable as possible. This means that the design department should try to avoid developing complex products and should focus on the development of components that are easy to manufacture and simple component groups that are easy to assemble. The following requirements for designing and developing products should be kept in mind:

- The design of parts and components should be made with an eye towards the manufacturing and assembly process.

- The configuration of the product structure must be designed following the modular design principle which means that the most possible end products should be able to be manufactured from the smallest number of individual components.

- Standardized components should be used to reduce and simplify the inventory of materials.

- The differentiation of products should only take place in the last steps of assembly if possible. This will allow for the fast reaction to specific customer requirements.

- Keep the number of parts in a product to a minimum and combine functions when possible.

- Make products easy to assemble by using or carrying out the following:

    - Component groups that can be preassembled
    - Purchased preassembled component groups
    - Consistent assembly direction (from above when possible)
    - Simplification of assembly procedures
    - Use time-saving connecting elements if they are used at all.
    - Exact tolerances must be defined. Parts with large tolerances should be used whenever possible to avoid or simplify any necessary adjustment work.
    - Only the minimum required degree of surface quality should be defined.
    - When designing individual components, make sure that they can be easily identified and classified as well as that they are easy to handle.
    - Use materials that can be substituted for and recycled.

Developers and designers have a great degree of influence and responsibility regarding costs. The decisions that they make will account for more than 70% of the cost of manufacturing and materials. Therefore, close collaboration between the design/development departments and the production planning and purchasing departments is necessary to make sure that important production and assembly factors are considered in advance. Making changes to the product design in the production or assembly areas can be extremely expensive.

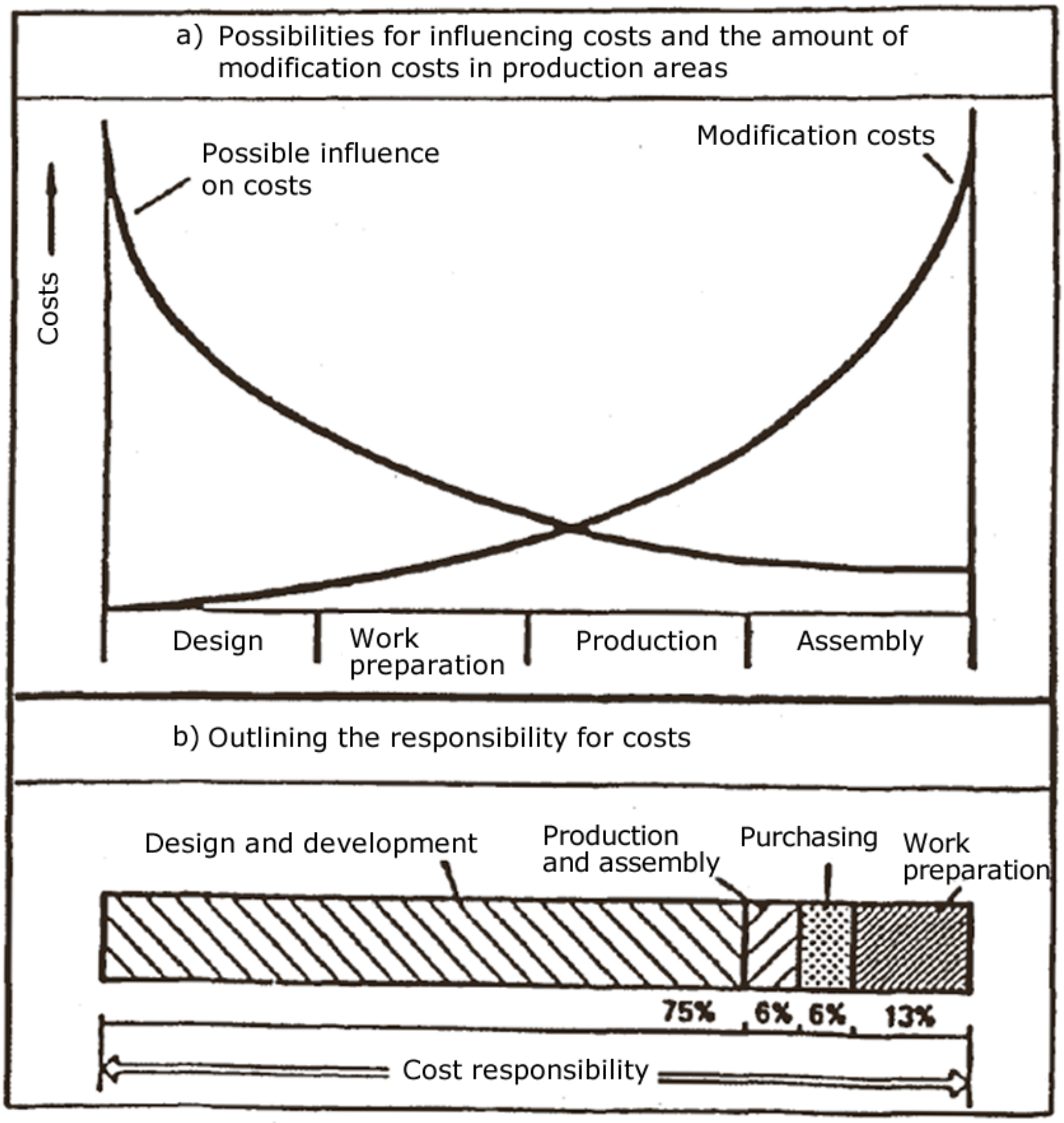


Figure 40: Influencing costs and cost responsibility

5. Outbound logistics

5.1 Task and importance

Outbound logistics, often called distribution logistics, refers to external transportation. External transportation refers to the flow of goods and associated information from production to the customer with the goods being staged according to the customer's wishes. This should be carried out while minimizing the expenses incurred by the storage of finished goods, commissioning, packaging, service, transport and handling. This interface between the customer and the supplier is an important part of the job order which includes the delivery date, delivery conditions, packaging, transport specifications, transfer provisions etc. Some important responsibilities are listed below:

- The delivery according to the customer's specifications regarding date, quantity, quality, price, etc. with possible additional services like customer oriented packaging units.
- Storage of the finished goods at minimal cost and in good quality conditions.
- Minimizing the inventory of finished goods.
- Minimizing the packaging costs and the use of packaging that both safeguards the product and is recyclable if possible.
- Minimizing shipping costs.
- Maintaining a high level of service.

The task of outbound logistics consists of the connection of the company's finished-product warehouse with customers through the planning, design, control and monitoring of the flow of materials and information. This task can be divided into three levels:

- Administrative level
  Includes the monitoring of the delivery market, market research, distribution planning, order processing, tendering invoices, monitoring delivery schedules, storage administration and planning.

- Planning level
  Includes management of the finished products, management of shipping, management of cargo areas, route planning, inventory optimization and monitoring the motor pool.

- Operating level

Four factors are very important to the customer:

- Quantity
- Price
- Schedule
- Quality

These services, along with additional customer demands, can be clearly defined and detailed in writing thus offering transparency to the customer.

Two factors are important to the company/supplier:

- The high cost factor (depending on the type of industry, this can be 15-30% of operating expenses) that must be minimized.
- The acquisitive effect of having the goods or services at an important place at just the right time can act as a form of marketing.

When developing an outbound logistics system, the goals should thus be:

- The fulfillment of needs and requirements of the market or those set by the company's marketing concept.
- The handling of the assigned tasks at minimal cost.

5.2 Influential variables on the design of an outbound logistics system

When designing an outbound logistics system, important variables must be considered and examined in relation to the tasks at hand. Most of these variables change over time and can be themselves manipulated. Some examples of these variables are below:

- Product assortments can consist of bulk goods or individually packaged goods, mass-produced or individual goods with production related parameters like quantity, dimensions, weight, shelf life, climactic requirements, etc.
- Production can be carried out according to specific customer specifications or series production for the anonymous market
- There are various customer structures such as wholesalers, retail businesses, individual customers, end users or intermediaries and geographic distribution dependent on the average size, quantity and regularity of the orders.
- Distribution can take place via a central warehouse, regional warehouses or direct delivery.
- The location of production can be in one single factory or in or multiple factories with a corresponding partitioning of the production program.
- There could be a marketing strategy with corresponding deadlines for delivery and ability to deliver in agreed upon quantities.
- There could be a competitive situation with special focus on customers and/or degree of service and the associated financial effects.
- Types of packaging may need to match customer specifications and dimensions with possible return transportation of empty packaging or packaging materials.

5.3 Types of transport and carriers

Selecting a type of transport is to a large degree dependent on the ability to react to customer demands and on the product assortment. The following criteria are important when selecting a carrier:

- Transport speed
- Transport quantity per time unit
- Handling requirements from the transfer of the goods to the shipper up to the transfer of the goods to the customer
- Properties of the goods being transported
- The current and anticipated market share

- The reaction speed to customer demands
- The cost and service level of the means of transport

Depending on the **means of transport**, there are various carriers that can be used. Some examples are below:

- **Shipping of individual goods**
  Uses rail or street transport and is carried out by a railroad company, post office, package service, courier service or the company's own fleet of vehicles

- **Bulk freight**
  Uses rail or street transport and is carried out by a railroad company, shipper or the company's own fleet of vehicles

- **Freight-car transport**
  Uses a railroad company and is usually only economical when both the supplier and the customer have access to railway connections because it is usually very expensive to transfer cargo from rail transport to street transport.

- **Street transport**
  This is the most common and flexible form of transportation. It is possible to have a shipping company handle the process or it can be handled by in-house vehicles. If it is handled in house, then the performance and costs of the motor pool must be considered and monitored.

  It is very difficult to compare one motor pool with another for a number of reasons:

  - Type of vehicles
  - Required special equipment
  - Degree of vehicle utilization
  - Job-related idle time during loading and unloading
  - Etc.

- **Water transport**
  Used for the transport of bulk goods, large parts or containers in river and ocean shipping.

- **Air transport**
  Used for the fastest possible shipping of containers, machines, packages, foodstuffs, etc. Air transport is becoming more and more important as it offers fast transport over very long distances with increasingly high freight capacity.

5.4 Outbound logistics systems

The following fundamental questions must be dealt with when designing an outbound logistics system:

- Which routes would be most economical and which services and service providers should be integrated into the system?
- What kind of carrier would be most economical and which services and service providers should be integrated into the system?
- What storage strategies would be most economical and which services and service providers should be integrated into the system?

The following options should be considered for transporting goods to customers:

Direct transport system

This involves the goods being shipped directly from the production hall to the individual customers using one of the previously mentioned shipping carriers.

Single-stage outbound logistics system with a centralized warehouse

The goods are transported from the various production locations to a centralized warehouse from the various production locations where they will then be shipped to customers using a carrier. The centralized logistics center can be in the form of a company-owned central warehouse, as a logistical profit center, a shipping company with integrated warehousing or a warehouse and distribution center belonging to a purchasing organization or wholesaler.

By concentrating a large assortment of goods from different industries and by servicing a large selection of suppliers and customers, the intermediate storage process, transport and handling can be designed much more effectively by the logistics center. This can result in further advantages due to, among other things, the concentration of investment and automation in the transport and storage areas as well as a reduction in the capital commitments required to ensure on-time delivery.

Multi-stage outbound logistics system with a centralized warehouse

The basic idea and the resulting advantages are similar to those with a single-stage outbound logistics system. The goods are transported from the production locations to centralized warehouses in logistical centers responsible for supplying specific delivery regions, e.g. Central warehouse I – Europe, Central warehouse II – USA. Individual customers are then supplied from these locations.

Combinations of outbound logistics systems

This system allows customers to be supplied both directly and indirectly. Large customers can be supplied by the production centers directly while smaller or individual customers can be supplied by a logistic profit center.

6. Disposal logistics

Companies have the responsibility to take back the packaging used for shipping products and sometimes the products themselves after they have been used by the customer so they can be recycled or reused. Public waste management or industry will then assume responsibility for the goods' disposal. Waste is to be sorted according to material to prepare it for recycling. There are many regulations regarding a wide variety of waste that is generated by a company. Disposal logistics no longer deals only with waste, but has now expanded to include the disposal and recycling of products that are no longer being used by the customer by monitoring and controlling the methods in which they are disposed of. The logistical chain of remainder materials is considered starting with their inception on through the possibilities for their disposal or recycling. Disposal logistics also determines the factors influencing the quantity and type of waste as well as the method in which it should be handled.

Disposal logistics' scope of responsibility has many parallels and similarities to production and distribution logistics. It is therefore rather common for these responsibilities to be distributed amongst other departments within the company.