Chapter 1
Tasks and Aspects of Modern Logistics

Consumers and companies need products, material and other physical objects at a time when and a place where they are generally not produced. This leads to the *task of operative logistics* or the *four rights of logistics* (4R):

- Logistics has to provide the ***r**ight quantities* of goods most efficiently at the ***r**ight place* in the ***r**ight order* within the ***r**ight time*.

The tasks of *analytical logistics* are to develop and organize optimal processes, structures, systems and networks for the operative logistics (Daganzo 1999). The main tasks of *logistic management* are to execute the orders and to fulfill the requirements of consumers and companies at lowest costs with adequate quality.

Objects of logistics are physical goods such as raw materials, preliminary products, unfinished and finished goods, packages, parcels and containers or waste and discarded goods. Also, animals and even people can be logistic objects, which need special care and service.

The *sources,* i.e. the *suppliers* or *senders* of logistic objects, are plants, factories, storages and warehouses of *producers, wholesalers*, and *logistic service providers*. The final *sinks*, i.e. the *destinations* or *receivers* at the end of the *logistic chains*, are the department stores, markets and sales outlets of retailers and the *points of consumption*. Not only the final customers, but also their suppliers are *receivers* of goods and products from other, upstream sources. In addition, producers, retailers and consumers are sources of empties, waste, used-up goods and other materials that must be removed. These sources, sinks and intermediate stations, linked by transport elements, make up a *logistic network*.

Logistics in a narrow sense takes the locations of sources and sinks as fixed and the ordered, produced and consumed quantities as given. Under this aspect, logistics has to execute only the *basic functions* shown in *Fig. 1.1*:

transport to bridge space
handling to adjust quantities
storing to bridge time
commissioning to fill orders
(1.1)

In addition *related services* are executed.

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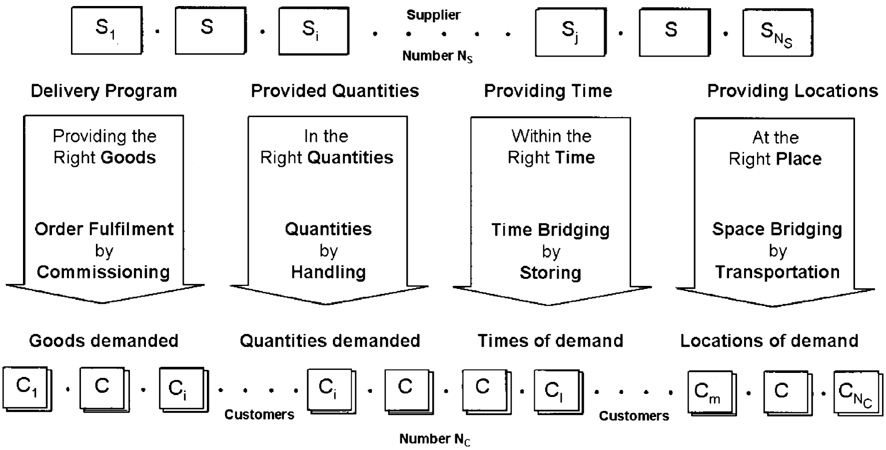

Fig. 1.1 Functions and tasks of operative logistics

The technology and intrinsic processes of mining, cultivation, production, manufacturing, assembling, and bottling are not part of logistics. Logistics has to *supply* these processes with materials and parts, to *distribute* the produced goods and to *remove* the arising waste and residual material. This implies more than just transport, storing and handling. It means:

- Logistics has to manage physical goods in *space* and *time* in order to execute *orders*.

Logistic systems which execute only the basic tasks (1.1) are special *performance systems*. Other performance systems which execute also non-logistic tasks are the subject of *logistics in a general sense*. In this sense, logistics has to design, set up, operate and optimize systems, which generate physical goods and immaterial services. These tasks overlap with *production planning*, *process technology*, *industrial engineering, operations research, informatics* and other fields of technology and economics.

Logistics in the broadest sense includes also *purchase* and *sales*. Sales representatives and purchasing managers negotiate the *terms of business* and the *prices* of goods and services. They initiate the supply processes and link the logistic chains between companies, customers and consumers.

Modern logistics is an interdisciplinary *applied science*. It uses the knowledge of other sciences for which logistics in turn is an *ancillary science*. This holds also for *informatics*, which deals with storing, processing, transferring and providing data and information. Although informatics plays an important role for the whole economy, it is for logistics, as for other disciplines, a mean to an end but not an end in itself.

In this chapter the elements and functions and the general processes, structures and organization of performance systems and logistic networks will be analyzed. In more detail, the functions and effects of *logistic centers* are explained. The last sections deal with *network management* and the *tasks of logisticians*.

1.1 Systems and Networks

A *system* is a set of *elements* connected by certain *relations*. *Networks* are systems, where the elements are stations or nodes and the relations are material or information flows between these elements. A *logistic system* is called *logistic network*, if the distances between the elements are far longer than the extension of the elements. This holds generally for *external logistic systems*. For *internal logistic systems* it depends on the distance of the observer.

The term *performance system* is a generalization of the term *machine system*. Therefore, many definitions and principles of the *theory of machine systems* and of *systems analysis* are transferable to performance and logistic systems (Bertalanffy 1968; Churchman 1970; Hubka 1973; Lenk/Ropohl 1978). A *machine system* executes *production orders*. It processes, transforms, handles and moves physical objects by a certain *technique*. Automatic machine systems operate *independent of persons* in a *deterministic* manner. They have only limited degrees of freedom. Examples of such machine systems are printing machines, chemical plants, and fully automatic assembly lines. Special logistic machine systems are *automatic high bay stores* (HBS), *sorter systems* and *automatic guided vehicle systems* (AGV).

Besides many analogies, there are fundamental differences between machine systems and performance systems. *Performance systems* depend on people and execute varying *customer orders* and *service orders*. Examples of *technical performance systems* are plants and factories but also logistic centers, traffic networks and company logistic networks.

Initiated by randomly arriving orders with different content, a performance system operates with *processes*, *throughputs* and *lead times*, which vary *stochastically* and are generally order-dependent. In order to cope with a varying demand, performance systems have several modes of operation and are partly de-centrally organized. While the *kinetic chains* of a machine system are defined by the *structure*, the *performance chains* of logistic systems and networks depend on *structure and strategies*. Therefore, a central task of *analytical logistics* is to develop strategies for the design and the operation of performance systems.

The functions of a performance system are determined by the requirements. Design, dimensioning and optimization of a system depend on the *customer* who specifies performances, outputs and objectives, defines the interfaces and frame conditions, and requires *quality* and *quantities*. For this purpose, the customer can choose between *result specification*, *functional specification* and *technical specification*:

- A *result specification* defines only the output and allows a variety of solutions. The methods, technology, structures and processes remain open.
- A *functional specification* determines processes and methods, thereby limiting the number of possibilities and solutions.
- A *technical specification* prescribes materials, elements and structure of the system in addition to methods and processes.

The goals and competencies of the customer and the type of the system determine the kind of the specification. For machine systems, a functional specification is supplemented by a technical specification of the critical elements. For internal logistic and performance systems, a result specification is combined with a functional specification of the critical processes. A pure result specification is adequate for external logistic systems.

1.2 Tasks and Objectives of Logistics

Every logistic task has certain aims, concerns a limited area and deals with defined aspects. Corresponding to *macroeconomics* and *microeconomics* (Mankiw 2003; Samuelson/Nordhaus 1998) the most general aspects of logistics are *macrologistics* and *micrologistics* (Ihde 1991).

The aim of *macrologistics* is to ensure the efficient supply of consumers, companies and state with goods and to organize the traffic flows between sources and destinations within a region, a country and around the globe. This is aimed independent of the ownership of the goods, sources and sinks. In order to achieve the optimal economical development of a country, besides capable institutions and suitable laws an efficient *logistic infrastructure* is necessary.

The aim of *micrologistics* is to supply – based on private orders, agreements and contracts – companies and consumers with the required goods most efficiently and to cover the *mobility demand* of individuals. For this purpose, companies and logistic service providers plan, set up and operate logistic systems and networks. The task of micrologistics is to realize and operate logistic systems and to manage transport chains and supply networks in order to fulfill the expectations of customers and to ensure the optimal development of a company.

The main area of micrologistics is *company logistics*. As shown in *Fig. 1.2* it comprises internal logistics and external logistics. *Internal logistics*, also called *indoor logistics*, *material handling* or *Intralogistics*, connects the receiving docks, internal sinks and sources, and the shipping docks of the same site, which can be a logistic center, transshipment point, plant or market. *External logistics* or *Extralogistics* connects the shipping docks of one or several locations with the receiving docks of other locations.

Depending on the direction of the material flows, it is common to distinguish between *inbound logistics* or *procurement logistics*, *outbound logistics* or *distribution logistics* and *reverse logistics* or *disposal logistics*. *Procurement logistics* focuses on the supply of goods from the sources to the companies. *Distribution logistics* deals with the delivery of goods from the companies to the recipients. Hence, procurement and distribution are two different aspects of the same task. Their objectives are determined either by the customer or by the supplier. From the customer's point of view, the supplier's distribution system is part of his own procurement system. Likewise, for the supplier the customer's procurement system is part of his distribution system.

Reverse logistics is the chronological reversion of supply. Tasks are to collect, transport, store and recycle or dispose production residues, consumer waste, packaging material, empties, depleted goods and worn out material. Special areas of

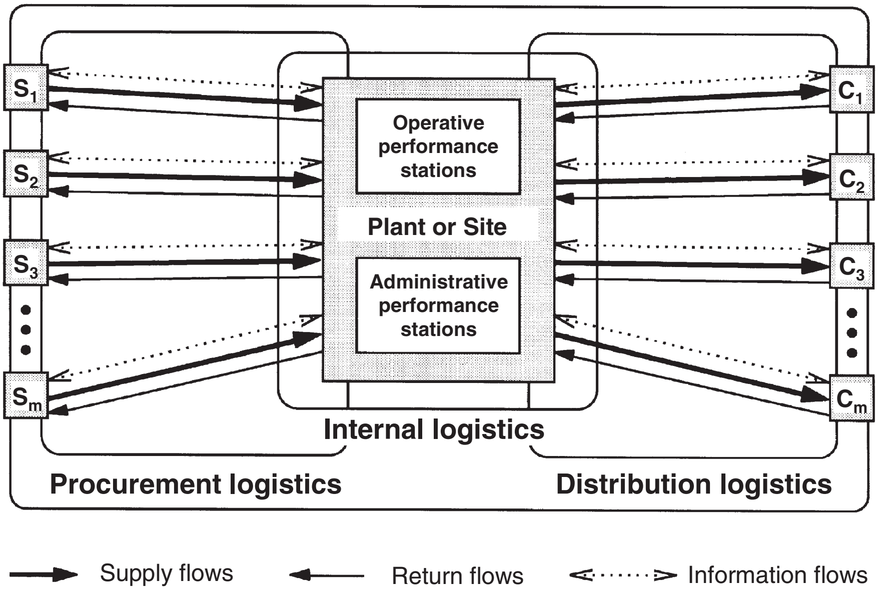

Fig. 1.2 Areas of company logistics
S_i: suppliers C_j: customers

reverse logistics are *garbage collection*, *waste management* and *empties logistics* (Dekker et al. 2004; Murphy 1996/2004).

Traffic networks and *transport systems* convey physical goods and people from departure points to destinations. The *nodes* or *stations* of a traffic network do not keep stocks. Their functions are junction and diversion respectively buffering, sorting, dispatching and other *transshipment services*.

The primary *objectives of company logistics* are:

performance
service quality (1.2)
cost efficiency

These are also the objectives for planning, realization and management of other performance systems. Their contents and priorities depend on the general goals of the company and the specific tasks of a project.

1.3 Structures and Processes

Performance systems are networks of stations generating certain services and performances. As sketched in *Fig. 1.3*, *material flows* and *data flows* pass through this network. Apart from the production and administrative processes within the stations, any performance system is a logistic system.

As in *hydrodynamics*, performance and logistic systems can be looked at from a stationary point of view under the *structural aspect* or from a dynamic point of

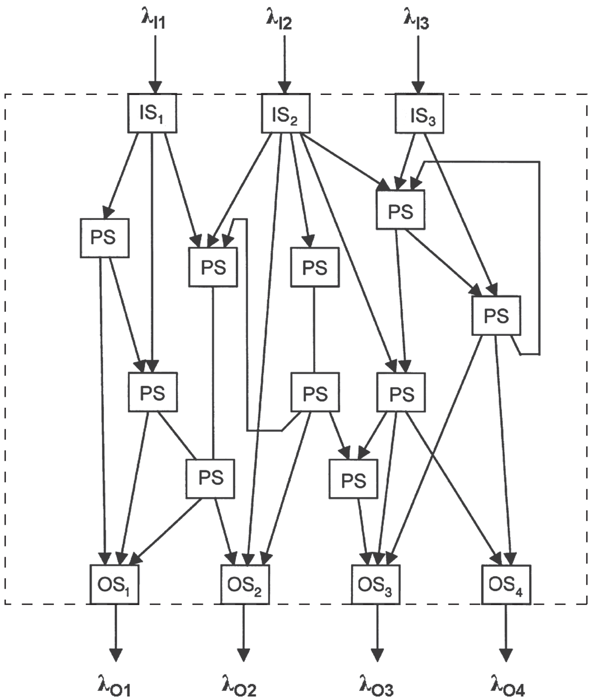

Fig. 1.3 General structure of a performance or logistic system

PS: performance stations
IS_i: incoming stations OS_j: outgoing stations
λ_{Ii}: incoming flows λ_{Oi}: outgoing flows
→ material or data flows   - - - border of the system

view under the *process aspect*. Some problems, such as process optimization, can be solved easier from the dynamic point of view. For other problems, such as design of systems or networks, the stationary aspect is opportune. For the tasks of modern logistics, both aspects must be considered. Hence, a logistician has to think in processes, structures and systems.

1.3.1 Structural Aspect

Under the structural aspect, a stationary observer analyzes structure, functions, capacities and performances of a system or network. From this point of view, the task of logistics is *system optimization* (Gudehus 1975/II; Lenk/Ropohl 1978):

- The logistic system or network has to be designed, dimensioned, organized and operated in order to fulfill the requirements most efficiently under specified restrictions.

The first step of system optimization is a *structure analysis* or *potential analysis*. By this analysis the stations and the configuration of the system are scrutinized in order to find out how well they execute the orders and how far they operate efficiently (see

Sect. 4.4 and *Fig. 13.29*). The assessment includes the *material flows* and *data flows* between and the *stocks* within the stations.

However, looking at a logistic system only from a stationary point of view involves the danger to lose sight of the processes. This is avoided by the *Chandler-principle* (Chandler 1962):

- Structure follows processes.

That means, processes and strategies should be developed before the structure is designed. However, this is only partly feasible, since the processes depend on the structure of the system.

1.3.2 Process Aspect

Under the process aspect, an observer follows the flows of goods and data on their way through the system. The observer scrutinizes the sequences of the activities in the logistic chains and the time consumption within the stations. The task of logistics from a dynamic point of view is *process optimization*:

- Out of a variety of possibilities, the most efficient processes and logistic chains meeting the requirements must be selected, designed and combined.

The first step is a *process analysis* aimed to recognize the efficiency of the stations in the performance chains (see *Sect. 4.3*). This analysis assesses whether the system meets the objectives of the customers, the specifications of the orders and the expectations of the recipients.

The basic *principle for process design* is:

- Only if all relevant processes in a system or network are known, it is possible to dimension the stations, to fix the connections, to calculate the costs and to reach the overall optimum.

A purely process-oriented approach often ignores *competing processes* and misses possible *synergies*.

1.3.3 Dynamic Network Aspect

Under the influence of *operations research*, theoretical logistics has dealt for a long time primarily with the optimization of *structures* and *networks* for *stationary and stochastic flows* (Bucklin 1966; Churchman et al. 1957; Daganzo 1999; Domschke 1985/1995; Domschke/Drexel 1995; Ford/Fulkerson 1962; Müller-Merbach 1970). In spite of the famous article on “Industrial Dynamics” by *J.W. Forrester* (1958), the dynamics of the flows in the supply chains have been widely disregarded until the end of the last century.

Supply chain management (SCM) focuses on the processes in the logistic chains from the suppliers of the suppliers, through the company to the customers of the customers (Christopher 1992; Cooper et al. 1997; Kuhn/Hellingrath 2002; Murphy/Wood 2004; Schönsleben 1998; Scott et al. 1991; Stadtler 2005). The pure process aspect of SCM, however, neglects the structures and the interactions between competing supply chains. SCM therefore often misses the synergies resulting from the multi-use of networks and resources (Bretzke 2008).

The performance requirements are generally *stochastic* and *vary in time*. Therefore, the central task of *company logistics* and *network management* is to design and to optimize processes *and* structures in order to obtain the optimal system for a stochastically fluctuating and dynamically changing demand (see *Sects. 1.9* and *2.9*). To support network management in this task, analytical-normative logistics has to develop *strategies for* planning, scheduling and operation of *dynamic systems*.

1.4 Elementary and Compounded Performance Stations

Performance systems as well as logistic systems consist of *elementary performance stations*. They are connected and arranged into *compounded stations*, *function modules*, *production plants*, *logistic centers* or *organization units*.

A general performance station as shown in *Fig. 1.4* is defined as follows:

- A performance station produces tangible and intangible goods due to orders or commands, using material and resources, such as persons, areas, buildings, machines and equipment.

The basic task of economic performance stations is to generate useful results and to create value at lowest costs. Under the *controlling aspect*, performance stations are *cost centers*, but not all cost centers defined by controlling are performance stations. Several performance stations located in the same site can be organized as a *function module*, *profit center* or another kind of *performance area* as shown in *Fig. 1.5*. Performance *areas* that produce similar goods or cover a specific part of a performance chain can be delimited and organized as an *organization unit*.

Organization units are plants, companies and business units where a *manager* or a *third party* is responsible for output, performance, quality and costs (see

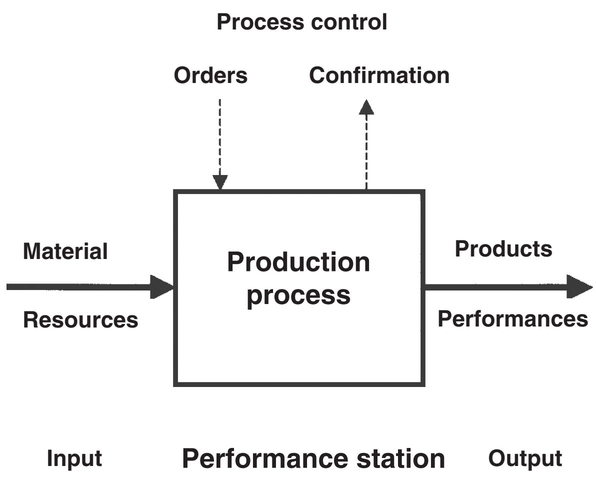

Fig. 1.4 Input and output of a performance station

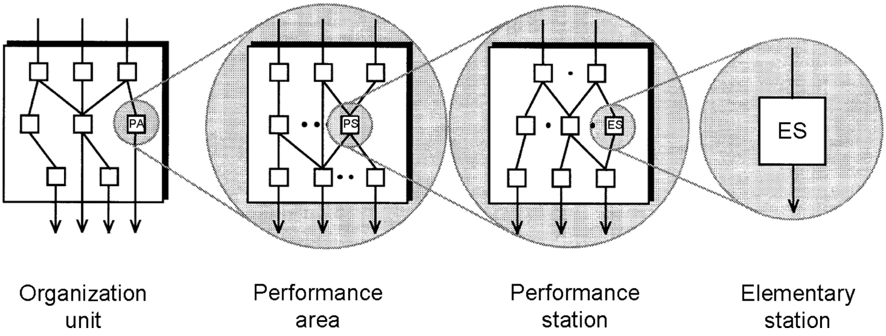

Fig. 1.5 Bundling and unbundling of stations and organization units

Chap. 22). In order to *call for tender* and to contract a *third party provider*, appropriate performance stations must be selected and delimited in an organization unit, which generates well specified services (see *Chaps. 7* and *22*).

The kind of the output, e.g. the properties of the products or the transport length and storing time, defines the *performance type*. Additional requirements are delivery times, storing conditions, safety regulations and quality requirements. For systems analysis and design, it is advisable to classify the performance stations corresponding to function, output or other features into different categories.

1.4.1 Output of Performance Stations

The output of a performance process can be tangible or intangible:

- *Tangible outputs* are physical objects such as material, buildings, industrial products, consumer goods or in general *products* that result from an extraction, production, manufacture, refinement, machining, assembling or filling process.
- *Intangible outputs* are the results of a transformation of space, time or information of physical and/or immaterial objects, such as rearranging, stacking, packing, coding, handling, transport or storing.

A process with a tangible output is called *production* or *manufacturing process*. Processes with intangible output are called *performance* or *service process*. However, the differentiation between a production process and a performance process depends only on the point of view or on the ownership of the goods. Refinement, assembling, bottling and packaging are considered part of the production process as long as these processes occur within the same company with own material. The same processes are called performance processes, or in the textile industry *passive subcontracting*, if a third party executes them with external material.

From the process aspect, the distinction between production process and performance process is not of much use, as the physical subject of the performance process carries with it the results of the consecutive process steps.

Output and *throughput* of performance stations are measured in *performance units*. Performance units for tangible outputs are the *measure units* for *weight* [kg; t], *length* [m, km], *area* [m^2] and *volume* [l, m^3] and the *number of pieces* or *load* *units* [LU]. Measures for intangible outputs are either the measures of the tangible goods undergoing the operation, or *activity units* such as *orders*, *positions* or defined scopes of services.

Special measure units for the basic *logistic performances* (1.1) are:

- *Transport performance units*: ton-kilometer [t-km], load-unit-distance [LU-km], pallet-kilometer [pal-km], passenger-kilometer [pass-km]
- *Handling performance units*: handling-unit [HU], load-unit [LU]; storage-unit [SU], handled item, piece
- *Storage performance units*: load-unit-time [LU-day], pallet-day [pal-d], square meter-month [m^2-month], car-parking-hour [car-hour]
- *Commissioning performance units*: order [Ord], position [Pos], pick unit [Pick], collection unit [CU = box, pallet, container, case]

1.4.2 Types of Performance Stations

The capability of a performance station is determined by its *limit performances*, i.e. by its maximal input, output and/or throughput. They depend on the number of functions a station can execute. Depending on the number of functions, monofunctional and multifunctional stations can be differentiated:

- *Monofunctional performance stations* can only execute one kind of process.
- *Multifunctional performance stations* can execute several different processes in *parallel* or in *sequence*.

The output of a performance station is either of *direct use* for the business, as for instance the result of an assembling line, or of *indirect use*, such as the services of a repair and maintenance station. *Internal performance stations* are located within the operating sites, buildings, or plants belonging to the company. *External performance stations* are located outside of the operating site or operated by a *service provider*. Depending on the objectives and required level of detail, it is either necessary to look at the elementary stations, or more advantageous, to consider combined stations (see *Fig. 1.5*):

- *Elementary* or *irreducible stations* cannot be separated without loosing their function. At one time they can execute only one specific process.
- *Combined* or *compounded stations* consist of parallel or serially arranged elementary stations. They can execute different processes simultaneously.

Another differentiation of performance stations results from the objects of the process:

- In *operative stations* physical objects are produced, processed, transformed, stored, moved or handled.
- In *administrative stations* orders, data or information are produced, processed, stored or transmitted.

In some cases an operative station executes also administrative tasks with order documents and accompanying information.

In a *transformation station* the incoming objects such as material, goods, parts or semi-finished products are transformed into other products and loose their identity, e.g.:

- *Converting stations* convert raw material in a chemical, physical or technical process into synthetic materials.
- *Manufacturing stations* form, combine and connect input material and parts into modules, semi finished or finished goods.
- *Assembling stations* erect and assemble vehicles, machines, constructions or buildings from parts, components and modules.
- *Filling stations* bottle or fill goods into bottles, cans, bags, containers or packages and generate *article units* or *primary package units*.
- *Packaging stations* are filling packages, parcels or boxes with article or logistic units and generate *secondary* or *tertiary package units* or *load units*.
- *Dismantling centers* take apart and sort discarded products for a further recycling process.

Service stations are operative performance stations where the incoming objects keep their identity, e.g.:

- *Control stations* identify, check, code and control physical objects without further change.
- *Treatment stations* execute any kind of service on material objects without changing them physically.
- *Repair stations* fix and mend defective products, transport means or used equipment.
- *Logistic stations* handle, sort, buffer, store and move physical objects, goods, products or load units without changing their properties.

Logistic service stations and pure logistic networks execute only logistic functions.

1.4.3 Key Figures of Performance Stations

A performance station can be characterized by the following key figures:

Services	types of orders service characteristics SC_i functions F_α transformation processes
Objects	properties of the incoming and outgoing physical objects type of incoming and outgoing data and information
Times	operating times, running times, working hours, processing and throughput times (1.3)

Static Limit performances	buffer and storage capacities for tangible objects memory capacities for data and information
Dynamic Limit Performances	limit performance of production μ_P limit performance of throughput μ_{ij}
Resources	areas and space equipment, machines and facilities conveyors and transport means personnel
Relations	location of the station operational and organizational relations links and interfaces to other stations

The *partial utilization* ρ_{ij} [%] of a performance station is determined by the *partial input, output* and *throughput rates* λ_{ij} [PU/TU], measured in *performance units* PU per *time unit* TU, related to the respective *partial limit performances* μ_{ij} [PU/TU], which are determined by the *cycle times* τ_{ij} [TU/PU] and *throughput times* T_{ij} [TU/PU] (see also *Fig. 1.6*). If operating times, machine running times and working hours are known and the scheduling and operating strategies are given, the required personnel, the number of equipment and the number of transport means can be calculated from the above key figures of the station by the formulas and algorithms which will be derived later in this book.

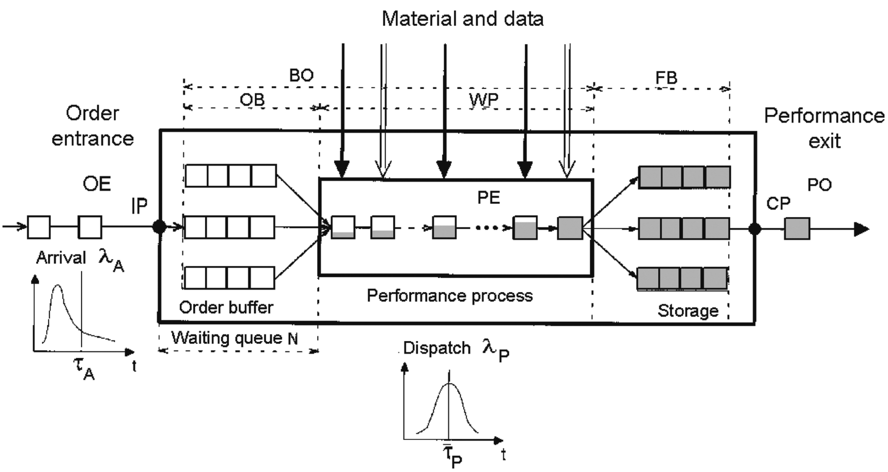

Fig. 1.6 Performance process and key figures of a performance station

IP: identification point CP: control point

$\lambda_A = 1/\tau_A$: input rate = 1/mean arrival time length

$\mu_P = 1/\tau_P$: limit performance = 1/minimal average cycle time

$\lambda_O = 1/\tau_O$: output rate = 1/mean leaving time length

OE: order entry PE: performance execution PO: performance output

OB: order buffer WP: work in progress FB: finished goods buffer

BO = OB + WP: back orders

1.5 Structures of Logistic Networks

Logistic systems and networks are performance stations linked by connections which transfer goods and information flows (see *Fig. 1.3*). The operative stations process, buffer and handle incoming flows of goods and convert them into outgoing flows. The administrative stations generate and process information and data that initiate or accompany the material flows of goods through the network and within the operative stations.

Storage systems, *commissioning systems* and *handling stations* are special logistic systems that execute only one or two of the basic logistic functions (1.1) (see *Chaps. 16*, *17* and *18*). *Transport systems* and *traffic networks* bridge spatial distances. They consist of *transport connections* and *transport nodes*. A transport connection links a departure station directly with an arrival station. By a transport node incoming transport flows are joined and/or branched into outgoing flows (see *Sect. 13.2.6*).

The number of intermediate stations determines the *stage degree* of a logistic chain:

- An *N-stage logistic chain* consists of N transport sections connected by N-1 *intermediate stations*.

In *Operations Research*, the stages of a chain or network are called *echelons*. In the *automotive industry* they are the upstream and downstream *tiers* as shown in *Fig. 1.15*.

The structure of a logistic network is defined by the *structure parameters*:

- number, locations and functions of the *sources* or *delivery points*
- number, positions, connections and functions of *intermediate stations*
- number, locations and functions of the *sinks* or *receiving points*

Intermediate stations can be *transport nodes*, *transshipment points* (TSP), *stores* or multifunctional *logistic centers*.

Some of the structure parameters, such as the locations of suppliers and customers, are *fixed points* which cannot be changed in short time. Other parameters, e.g. the number and locations of intermediate stations, are variable and can be used as *design parameters*. For known performance requirements and restrictions, it is possible to optimize a logistic system or network by varying these parameters.

A further option for extended networks is to connect sources and sinks with high exchange flows directly, while letting weaker flows of goods run over two, three or more stages. This procedure results in a *hybrid network* (Bretzke 2008) with *mixed structure*, which is a *superposition* of systems with different stage degree (see *Figs. 1.15*, *21.22* and *21.24*).

In order to explain the structural possibilities and to discuss the basic characteristics of logistic networks, it is useful to investigate networks with only one stage degree. In practice, generally hybrid networks with mixed stage degree must be considered (see *Chap. 21*).

1.5.1 Single-Stage Networks

As shown in *Fig. 1.7* a single-stage transport network has only direct connections by *unbroken transports* between sources and sinks.

As long as the transport means are fully utilized by the consignments to be transported from a source to a sink, a *non-stop delivery* by a *one destination transport* is most efficient. If a source supplies several sinks in a surrounding *service area* with smaller consignments, it is opportune to execute *mixed destination transports* on longer *delivery routes*. Smaller consignments from many sources in a surrounding area are collected in a *mixed source transport*, also called *milk run* (see *Fig. 21.5*).

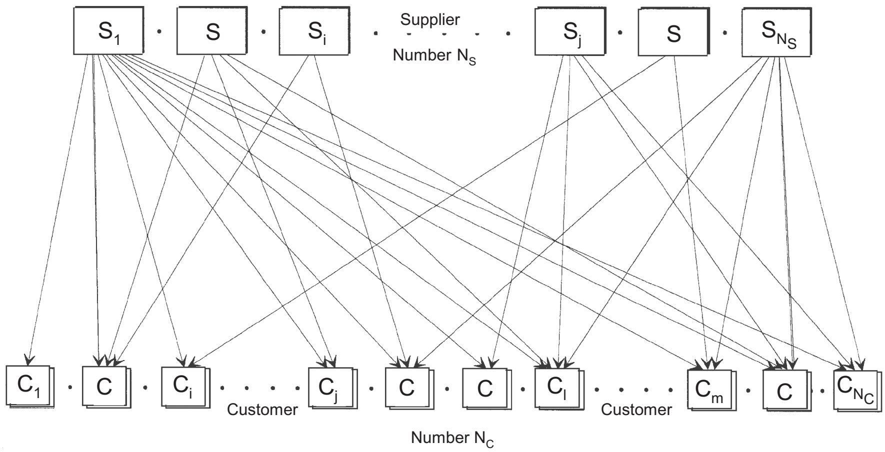

Fig. 1.7 Single-stage transport network for direct delivery
S_i: supplier C_j: customer

1.5.2 Two-Stage Networks

In a two-stage network, sources and sinks are separated by one intermediate station. That can be a stockless *transshipment point*, a *store* or a *logistic center*.

A two-stage transport network is opportune, if a small number of delivery points has to be supplied from many far-off sources, provided direct transports are not efficient. The transshipment points then are located as *collection stations* in the centers of the *source areas*.

If only if a small number of sources has to supply many, widely spread and far-off recipients, it is opportune, if direct transports are not efficient, to convey the goods via transshipment points that serve as *distribution stations* and are located in the center of the *destination area*.

1.5.3 Three-Stage Networks

When supplying many recipients from many far distant sources with small quantities, a three-stage network structure can be opportune. The connections between the sources and sinks in a three-stage network are twice broken. This is possible by passing through two consecutive transshipment points of a *freight network* as shown in *Fig. 1.8*, or through a *logistic center* followed by a transshipment point as shown in *Fig. 1.9*.

The collection stations are located in the areas of the sources, the distribution stations in the areas of the recipients. In a transshipment point as well as in a logistic

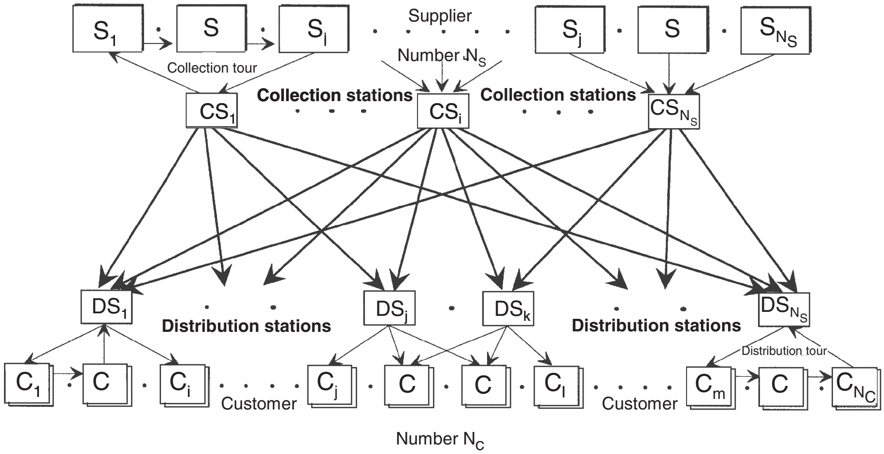

Fig. 1.8 Three-stage freight network with transshipment points for collection and distribution

S_i: suppliers C_j: customers CS_i: collection stations DS_k: distribution stations

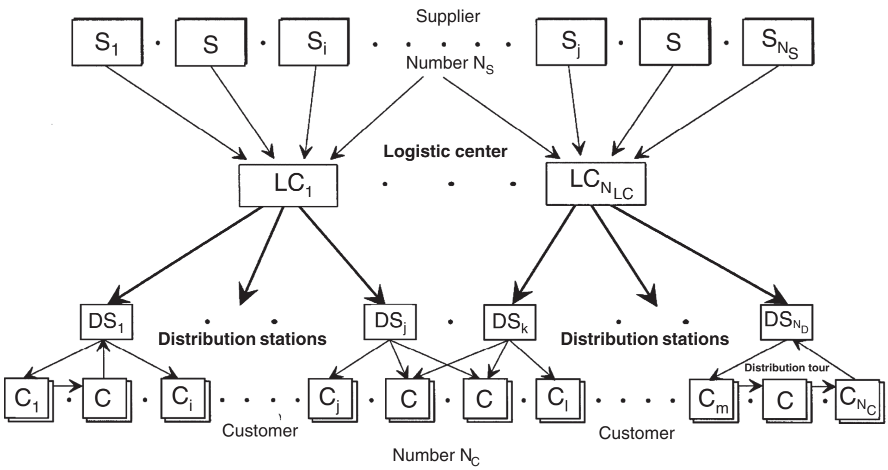

Fig. 1.9 Three-stage logistic network with logistic centers and distribution stations

LC_n: logistic centers

center, the handling of the goods for freight consolidation can be organized as *cross-docking* of complete load units without sorting or as *transshipment* which implies sorting of single packages (see *Section 21.1.4*). *Main leg transports* bridge the long distances between the collection and distribution stations.

The transport costs in a three-stage freight network can be considerably reduced by *load consolidation* in the transshipment points, selection of most economic transport means, combining outbound and return freights in the *main carriages,* and by optimal collection and delivery tours.

A further possibility to minimize logistic costs and to improve the logistic service is to allocate *additional services* in the *transshipment centers*. In a partly centralized organization, the functions of several storekeeping stations are bundled as shown in *Fig. 1.9* into one or a few *logistic centers* without increasing the number of stages.

1.5.4 Multi-Stage Networks

In a multi-stage network, the connection between sources and sinks is broken more than twice. Four-stage logistic networks as shown in *Fig. 1.10* result if one or more *logistic centers* with central stocks and additional services are inserted between the collection and distribution stations. Multi-stage *global freight networks* emerge in the *multimodal transport* when using air or sea transport for the long distances, rail transport for medium distances and road transport for local pickups and deliveries (see *Figs. 21.4* and *21.21*).

In most cases, the logistic network of a company is a *superposition* of networks with different stage-degree. Logistic chains with different stages and deviating distances, throughput time and performance costs connect the sources and sinks. From these, the *scheduler* has to select the optimal chain that fulfills the required delivery times at lowest costs.

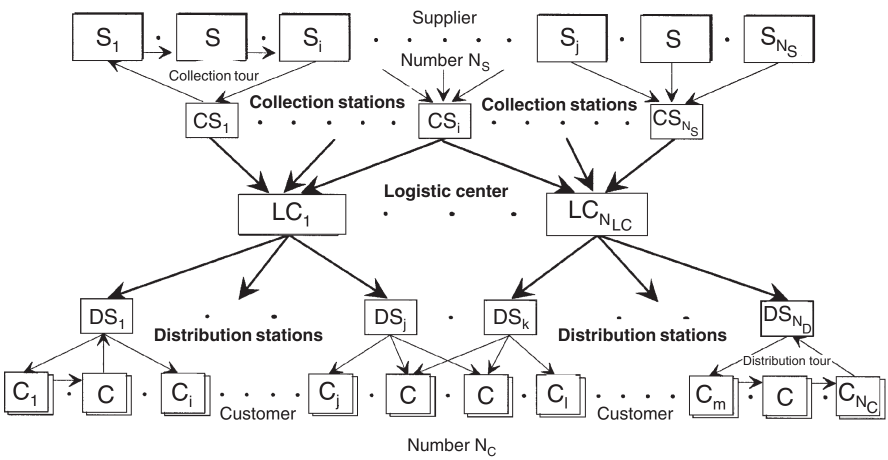

Fig. 1.10 Four-stage network with collection and distribution stations and several logistic centers

1.6 Functions of Logistic Centers

In a *logistic center* several logistic functions are bundled as shown in *Fig. 1.11*. It offers a wide range of services and consolidates procurement and distribution flows in order to reduce handling and transport costs.

An *open logistic center* consists of several buildings or handling places surrounded by traffic areas and directly connected to external roads, railway, waterways or airports. Examples for open logistic centers are railway stations, airports, harbors and seaports comprising the sites of several logistic service providers. Other examples are *city logistic centers* located at the periphery of metropolitan areas and big cities. They are a combined source and sink for *city logistics* that aims to consolidate freights into and out of the service areas (Taniguchi 2001).

A *confined logistic center* is made up of performance stations and functional modules located in a separate building or site. Generally, confined logistic centers are connected directly to the external road network. In some cases they have a link also to the railway net, a waterway or an airport.

A confined logistic center can be the operating site of a manufacturer, wholesaler or retailer or of a logistic service provider. Examples are *consolidation centers* (CC), *distribution centers* (DC) and *shipping centers* (SC), *local warehouses* (LWH) and *central warehouses* (CWH), *transshipment points* (TSP), *regional distribution centers* (RDC) or *freight terminals* (FT). Most logistic centers can execute the *basic operative logistic functions*

transfer of goods for many suppliers and customers
storekeeping for one or more suppliers or customer (1.4)
commissioning for many customers

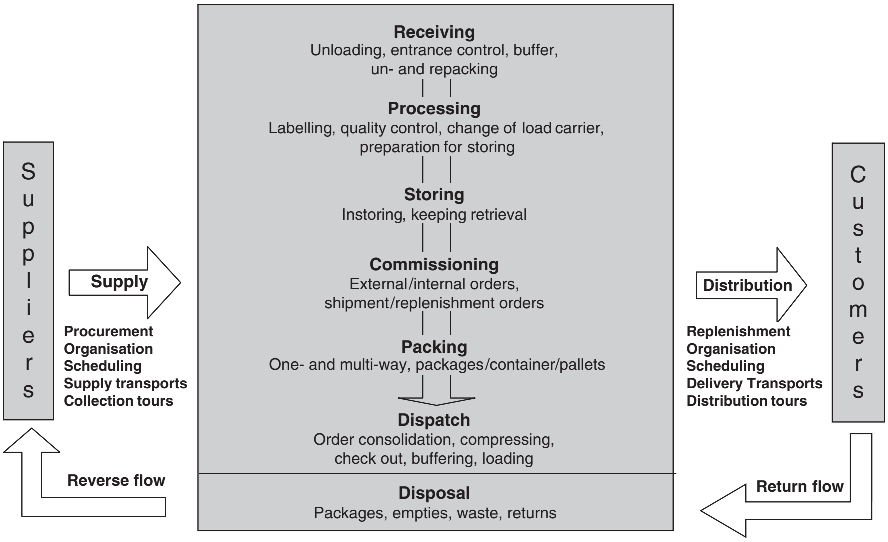

Fig. 1.11 **Functions of a logistic center**

For this purpose, they have the *standard functional areas*

receiving area
storage systems
commissioning systems
internal transport systems (1.5)
sorting systems
dispatch area

Many logistic centers offer *additional services* or *added values*, such as (Stock/Lambert 2001; Murphy 2002):

quality control
bottling and packaging
wrapping and unwrapping
building up and braking down load units
cutting and weighting (1.6)
assembling
repair and maintenance
handling of returns and reclamation
handling of empties

These services are executed in special functional areas such as *quality control*, *return reception, reclamation* or *repair and maintenance stations*.

Apart from the operative functions and services, logistic centers generally execute *administrative services* such as

scheduling of external transports and freight
inventory management and stock controlling
customs clearance
invoicing (1.7)
order scheduling
data processing

The operative areas (1.5) of a logistic center with the standard functions (1.4) and the different *internal logistic chains* are shown in *Fig. 1.12*. A logistic center with a wide scope of *added values* such as (1.6) and (1.7) is also called *competence center*.

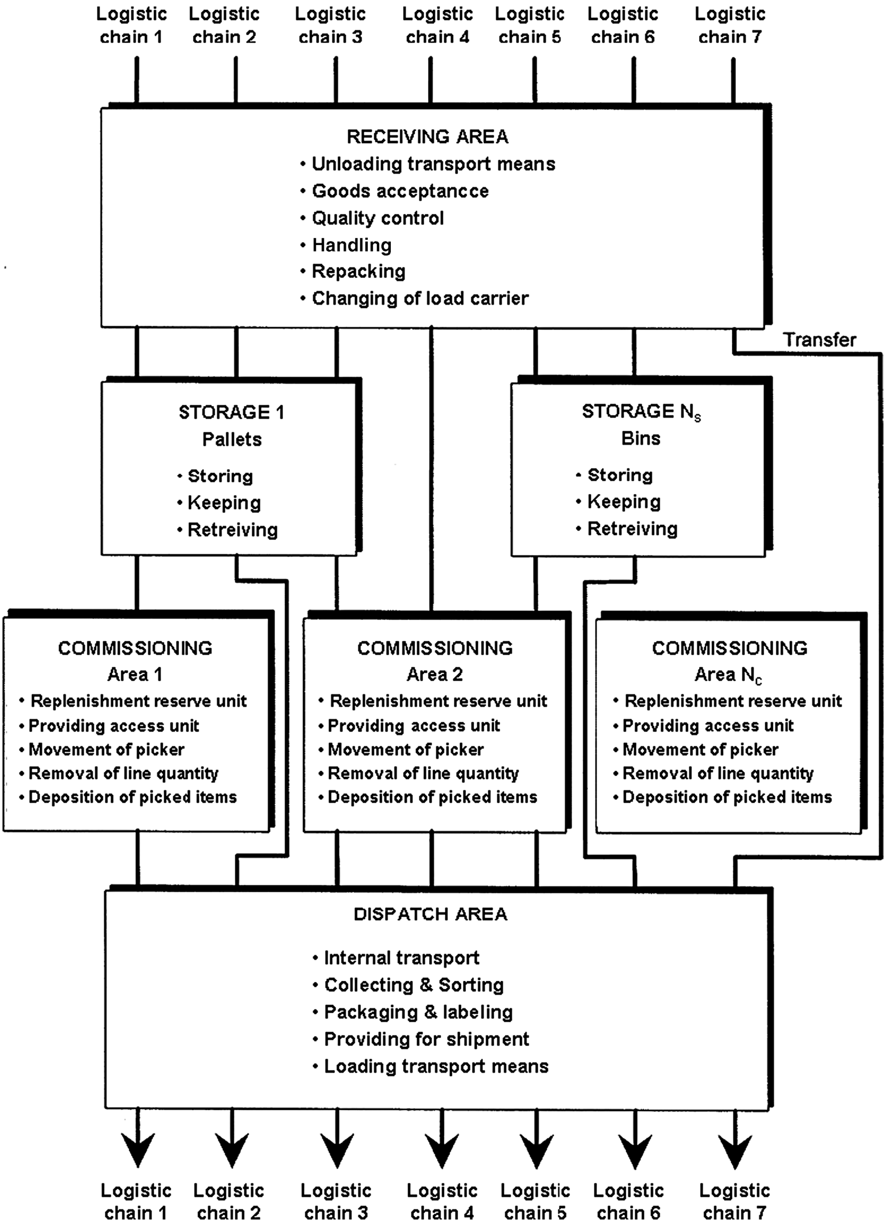

Fig. 1.12 Operative performance areas and internal logistic chains of a logistic center

1.7 Process Chains and Logistic Chains

A chronological sequence of operations executed in a spatial chain of organization units and performance stations which results in a product or service of certain value is called *process chain*, *performance chain* or *value creation chain*. Depending on whether the operations take place in operative or administrative stations and whether they refer to tangible or intangible objects, a performance chain is called *logistic chain*, *information chain* or *order chain* (see *Fig. 1.13*):

- A *logistic chain* is a sequence of operative stations passed by material objects. In- and outgoing objects of logistic chains are material, goods or load units that change in time, space and sequence during the process. The flow of goods through a logistic chain is called *material flow*.
- An *information chain* is a sequence of stations passed by data or information. The in- and outgoing objects of an information chain are intangible. The flow through an information chain is called *information flow* or *data flow*.

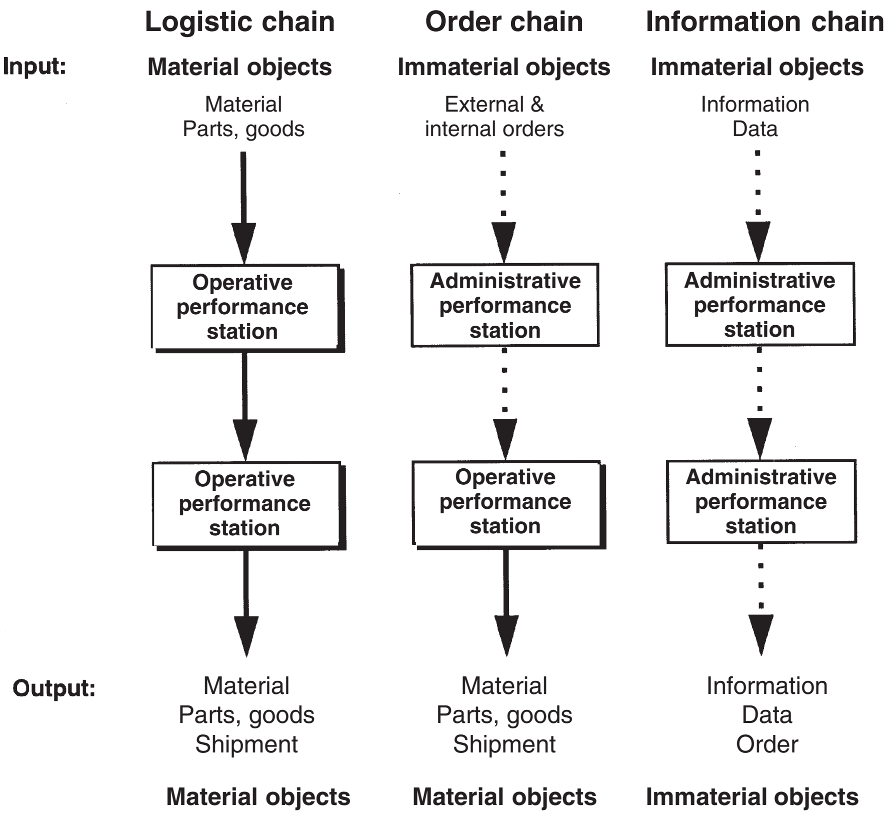

Fig. 1.13 Logistic chains, information chains and order chains
→ material flows - - -> data flows

- An *order chain* is a sequence of administrative and operative stations passed first by orders and later by the generated objects. The administrative stations accept, process and control the orders. The following operative stations execute the production or service orders.

The incoming objects of an order chain are immaterial orders. The outgoing objects are either tangible, such as products or load units, or immaterial such as services or information (see *Fig. 3.6*). A logistic chain reflects the complete delivery process from a supplier to a customer. The order chain describes the order process from the customer and back to the customer. In many cases the logistic chain is triggered by an order chain and goes along with an information chain. Information chains and logistic chains meet at so-called *identification points* (IP) and *control points* (CP) (see *Sect. 2.6*).

In many cases, for the execution of the same order several order chains are possible. It is the task of supply chain management to identify, depending on the kind and content of the orders, the most favorable process chains and to design them according to the requirements.

A *complete performance chain* includes all performance stations between a source and a sink. It can be split up into external and internal logistic chains:

- *External logistic chains* consist of stations outside a company and of transport connections between shipping locations, transshipment points, logistic centers and destinations.
- *Internal logistic chains* consist of stations and connections inside a company, station, site, transshipment point or logistic center.

Design, set-up and optimization of external logistic chains will be outlined in *Chap. 21*. *Internal logistic chains* are the possible process paths of physical goods from the entrances through the operative stations (1.5) to the exits of a plant or site. For a logistic center, they are shown in *Fig. 1.12*. Internal logistic chains start in the *goods receiving area* with the following handling and administrative activities:

unloading of arriving vehicles
receiving of goods
quality control (1.8)
unpacking and repacking
building up storage units

For *transfer goods* and *transit units* that are not kept on stock but only transshipped, the processes in the receiving area are followed by a *direct transport* via a *bypass* to the dispatch area. The transfer of arriving goods on unchanged pallets is called *crossdocking* (see *Sect. 21.1.4*).

If the incoming goods are kept on stock, the processes in the receiving area are followed by a transport to the storage area, where the three *steps of the storage process* are executed (see *Chap. 16*):

in-storing of the storage units
keeping the storage unit on a storeplace (1.9)
retrieval of the storage unit

If not only full loads units but also *single items*, *mixed load units* and *sorted load units* are required, the storage process is followed by *sorting* and *order picking* which is called here *commissioning*. The *steps of the commissioning process* are (see *Chap. 17*):

replenishment of reserve units
providing of access units
movement of the order picker (1.10)
gripping of the order line quantity
deposition of the picked items

Internal logistic chains end with the transport to the *dispatch area* where the following activities are executed:

sorting and consolidating
packing and labeling
compressing and sealing
preparing for shipment (1.11)
final control and checkout
transport to the loading dock
loading of the waiting vehicles

In the stations of a logistic center the above activities are executed in parallel or successively. The single activities, the allocation to the different stations, the combination of these stations and their position within the logistic center differ from case to case.

If for the different *article clusters* several parallel storage and commissioning systems exist as shown in *Fig. 1.12*, for some articles more than only one internal logistic chain is possible. To find out the most efficient internal logistic chain, appropriate *selection strategies* are needed.

1.8 Effects of Logistic Centers

The total *logistic costs* for delivering goods via a logistic center are caused by the following *partial costs*:

- *transport costs* for the shipment from the sources to the center
- *interest costs* for the inventory capital
- *performance costs* for the functions within the logistic center
- *distribution costs* for the delivery from the center to the recipients

These partial costs depend on the degree of consolidation of procurement, inventories, functions and distribution. A further factor of influence is the *number of logistic centers* between delivery points and receiving locations.

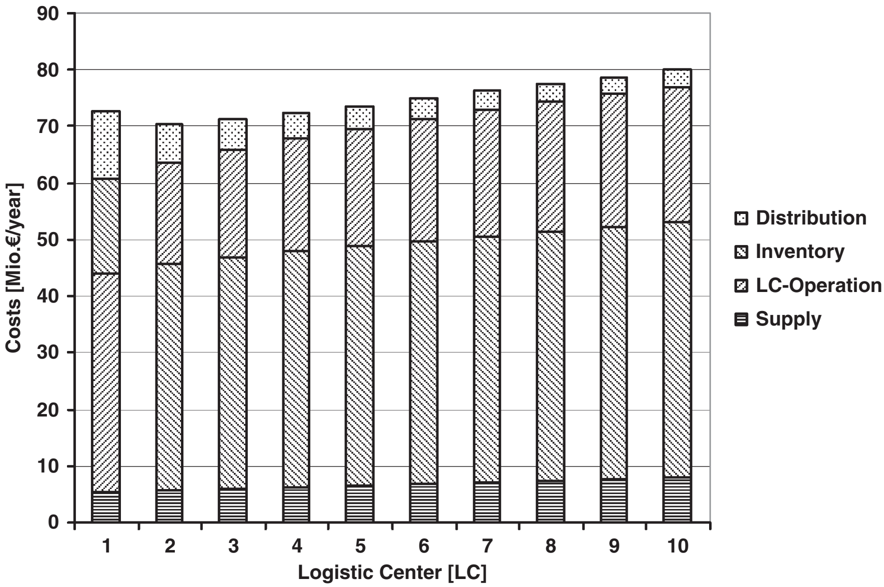

Fig. 1.14 Dependence of the total logistic costs on the number of logistic centers
procurement network of a German retailer with 250 outlets
network structure see *Fig. 1.9*, supply chains see *Fig. 21.23*

The partly opposite influences of the partial costs lead to the *optimization rule*:

► For any given set of requirements and restrictions exists an *optimal number of logistic centers*.

One example is presented in *Fig. 1.14*. It shows the optimization of the *procurement network* of a *department store retailer* with a structure as outlined in *Fig. 1.9*. The total costs first decrease with decreasing number of logistic centers, until a flat minimum is reached for the *optimal number of logistic centers*. For the example the optimal number is 2. The total costs for only one logistic center increase as the distribution costs increase extremely. In this *business case*, it was possible to reduce the total logistic costs by about 12% and to improve service level and logistic quality by consolidating the functions, stocks and flows of goods from formerly 10 regional warehouses in 2 logistic centers.

1.8.1 Procurement Consolidation

The consolidated shipment of many small procurement orders in large load quantities via a logistic center reduces the costs for the suppliers. It simplifies scheduling and improves the utilization of production facilities. The costs for order processing, operations, storing, commissioning and dispatch also decrease.

By procurement consolidation, the total logistic costs can be reduced in a range from 2 to 5% of the purchase prices, depending on the type and value of the goods and on the depth of manufacturing. The negotiation of more favorable terms of delivery, such as quantity discounts, just-in-time-delivery or the use of standard load units reduces the costs further and contributes to improving the competitiveness of all participants in the supply chains.

1.8.2 Consolidation of Inbound Flows

The consolidation of many smaller shipments from one supplier to many customers into a few shipments to one or two logistic centers reduces the number of inbound transports without changing the transport frequency. At the same time the quantity per shipment increases.

The utilization of standard load units such as *EURO-pallets* or *ISO-containers* is improved by higher filling rates. Also, the utilization of the transport means is improved. Vehicles with larger capacity, such as semi-trailers, trailer trains, swap trailers or wagons, and transport networks with lower specific costs, such as railways, can be used. In addition, efficient loading techniques reduce costs.

The mean travel distance of the inbound flows of goods can be minimized by locating the logistic center in the *transport gravity center* of the shipment points (see *Sect. 18.11*). Compared with the mean travel distance of direct deliveries, the travel distance of consolidated inbound flows can either be reduced or at least kept constant. From this follows the *rule*:

- The costs of the inbound flow of small shipments from many sources can be reduced by consolidation via a logistic center.

As shown in *Fig. 1.14*, the costs for the inbound flows cause between 5 and 10% of the total logistic costs. In the considered business case the relevant costs are reduced up to 25% by replacing 10 regional distribution centers by 2 logistic centers.

1.8.3 Consolidation of Stocks

By consolidating the stocks of the same goods from many regional warehouses in a central store, either the total stock level can be reduced remarkably while maintaining the service level, or the service level can be improved without changing the stock level. This, however, holds true only with optimal *inventory management* (see *Chap. 11*).

According to the *square root law of stock centralization* (Maister 1976), which will be proved in *Sect. 11.10*, the stock levels of two regional warehouses with the same throughput can be reduced by a factor $1/\sqrt{2} = 0.71$, i.e. by about 30% if centralized in one logistic center. At the same time the inventory turnover is increased by the inverse factor of the stock reduction. That means by consolidation of two equal stocks of the same range of articles in one central store the *inventory turnover* can be increased by the factor $\sqrt{2} = 1.41$. From this follow the *rules of stock centralization*:

- Stocks, inventory capital and interest costs can be reduced by a smaller number of storage locations.
- Space demand for storeplaces and storage costs decrease with increasing storage capacity.

- Centralization of many local stocks in a few logistic centers reduces the inventory turnover and hence the costs for in- and out-storing and handling.

As explained in *Chap. 11*, these effects are achievable for articles with a continuous and sufficiently predictable demand. Other stocks that cannot be influenced by scheduling, such as buffer stocks or the stock for *sales promotions*, reduce the effects of stock consolidation.

For the above example the interest costs for the inventory capital are in the range between 25% and 35% of the total logistic costs. By 2 logistic centers instead of 10 regional warehouses, inventory capital and interest expenses are reduced by 20%. The costs for running the two logistic centers further decrease by the smaller space needed for the stock, by the increased inventory turnover and by other consolidation effects such as the lower specific costs of an automatic high bay store.

1.8.4 Bundling of Functions

Provided the logistic center is optimally designed, dimensioned and organized, the bundling of the logistic functions (1.4), (1.5), (1.6), (1.7), (1.8), (1.9), (1.10) and (1.11) has the following positive effects:

- increased efficiency of operations and administration
- applicability of more efficient technique
- reduced share of partly filled load units and storage units
- use of standard load units with optimal dimensions
- decreasing handling costs
- lower costs due to the reduced number of storeplaces
- chances to balance and compensate peaks of demand
- opportunity to operate facilities round-the-clock
- reduced administration costs by modern IT
- lower total overhead costs for the smaller number of locations

The most interesting contributions to the savings are the decreasing investment with increasing storage capacity and the reduction of handling cost rates with increasing turnover.

For example, an *automatic high bay store* with capacity for more then 10.000 pallets and high throughput rates which is operated round-the-clock has lower storage cost rates by a factor of 3 than a conventional store served by forklift trucks. Automatic high bay stores are only one example for efficient technology and modern logistic systems. Their potential can only be captured within large logistic centers (see *Chaps. 16*, *19* and *21*). Another possibility of efficient consolidation of functions is the transfer of order picking from regional warehouses or from the delivering vehicles to a logistic center. Normally, the *general rule* holds:

- The costs of internal logistics decrease with the number of logistic centers.

The extent of cost savings by consolidation of functions in logistic centers varies from case to case. In the above example, the internal logistic costs, which amount here to 50–60% of the total logistic costs, were reduced by 15% by consolidating the functions from 10 regional warehouses to 2 logistic centers. In other cases the savings were even higher.

1.8.5 Consolidation of Distribution

By consolidating many single shipments to customers or outlets in a few big shipments via a logistic center, the delivery transports can be reduced substantially. At the same time the transport quantities increase.

As for the inbound flow, standard load units and vehicles with large capacities can be used for the long-distance transport from a logistic center to distribution stations, outlets and key accounts. By this means, the transport capacities are better and more evenly used and the share of *less-than-car-loads* and *less-than-truck-loads* is reduced.

The *area coverage*, i.e. the delivery from the regional distribution stations to the single customers, can be executed by local *freight forwarders*. Logistic centers that are located near metropolitan areas can also participate in the *city logistics*. The consolidation of delivery tours for many companies leads to additional optimizations, which consequently relieves regional and local traffic (Bock et al. 1996).

These effects of a consolidated distribution and better area coverage are partly compensated with decreasing number of logistic centers by the longer distances to the customer locations. If the long-distance transports are not executed by rail, logistic centers can cause higher traffic on the roads. Therefore, the *general rules* hold:

- ▸ With decreasing number of logistic centers, the delivery frequencies can be reduced and more efficient transport means used.
- ▸ Longer travel distances in extended distribution areas cause higher distribution costs although the transport frequency is decreasing with the number of logistic centers.

Figure 1.14 shows the dependency of distribution costs on the number of logistic centers for the considered department store. The costs for distributing to the single department stores from only 2 logistic centers instead of 10 regional warehouses increase by the factor 3. This leads to a contribution of the distribution costs to the total logistic costs of about 14% instead of 4%. The savings generated by 2 logistic centers are partly compensated by the higher distribution costs as shown by the total cost curve in *Fig. 1.14*.

1.8.6 Additional Effects and Potentials

The implementation of logistic centers with high throughput and central stocks leads to attractive saving potentials compared to regional logistic stations. Practice shows that the cost savings by consolidation of transports and functions are often higher than in the above example.

The savings depend critically on the total structure of the logistic network, on the right design and selection of the supply chains and on the proper layout and competent management of the logistic centers. Methods, strategies and solutions for this purpose will be developed throughout this book.

The employment of a competent *logistic system provider* for the operation of a logistic center and for the execution of the inbound and outbound transports can lead to further cost savings and service improvements. A system provider has the option to achieve additional *synergy effects* by using a *non-dedicated logistic center* for several customers (see *Chap. 22*).

1.9 Network Management

In war times holds (Gardiner 2006): “The scope and success of all *military operations* are completely dependent on what can be achieved logistically”. The same is true in peace times:

- Scope and success of business operations critically depend on what can be achieved logistically.

That is determined mainly by the quality of the *network management*.

The logistic network of a company, institution or household is part of an extended network that goes far beyond their direct influence. Therefore, it has to be decided first where to set the limits of the own logistic network. The objectives of *network management* result from the kind of business and the type of the logistic network in which a company operates. This can be a temporary, permanent, flexible and a combined network.

1.9.1 Temporary Logistic Networks

Temporary networks are set up for a limited time in order to serve a temporary demand. Examples of temporal and spatial limited networks are the logistic networks of building sites, exhibitions, fairs, events and development projects:

- The management of temporary logistic networks is task of *project logistics.*

Project logistics is the core competence of companies that are specialized in the execution of major projects in alternating locations. Examples are *building site logistics* of corporate building groups (Kulick 1981), *plant logistics* of engineering companies, *object logistics* of event organizers and the *disposal logistics* of demolition and salvage companies. Central tasks of project logistics are *development* of a temporary logistic network, *assignment* of specialized service providers, e.g. for furniture, heavy load or bulk goods, and *management* of the logistic network and sites.

If the projects are nonrecurring events, such as relocation of an office, trade fair participation or a building project, it does not make sense for the company, to have an own project logistics department For these special purposes, qualified *project logistic providers*, such as *moving companies* or *building site providers*, are available on the market.

1.9.2 Permanent and Flexible Networks

Permanent networks are set up for unlimited time in order to serve a long lasting demand. The continuity of the demand and the frequency and size of the orders determine the network:

- *Permanent* or *fixed logistic networks* consist of logistic stations at fixed locations, such as receiving stations, transshipment points and logistic centers, that are connected with each other by a permanent transport net.

Many *logistic network provider*, e.g. freight forwarders, railways, postal, courier, express and parcel services and airlines, are owner of a permanent logistic network. The procurement networks of retail companies with *dedicated logistic centers* and regional warehouses are also fixed logistic networks (see *Sect. 21.12*).

As in electricity industry, a permanent logistic network is opportune for a continuous basic demand, since with permanent high utilization of the installed limit performances and capacities the performance costs of a fixed network become minimal. However, the flexibility of a fixed network is generally rather low. Hence, for seasonal or stochastic peak demand that exceeds by far the basic demand, a flexible network is opportune:

- *Flexible* or *virtual logistic networks* are networks with changing stations, varying transport links and altering partners involved.

The operating costs of a flexible network are generally higher as for a fixed network. Operators of flexible networks, who own no transport means and have no permanent operation sites, are the so-called *Fourth Party Logistic Service Providers* (4PL) (see *Sect. 22.3.3*).

According to the demand, a fixed regional or national network can be connected with flexible local or global networks thus resulting in combined networks:

- *Combined networks* consist of a number of fixed stations connected by regular main transports in combination with flexible local networks and spontaneous relation transports.

The procurement and distribution networks of large car manufacturers, chemical companies and consumer goods producers with plants and suppliers around the globe are such combined networks.

As an example *Fig. 1.15* shows the logistic network of a car manufacturer whose module suppliers are located close to the assembly plant. The *procurement network* of the factory ranges upstream from 2nd and 3rd *tier suppliers* of parts and components to the 1st tier of the module suppliers. The *distribution network* reaches downstream from the end of the assembling line and a central warehouse for accessories and spare parts over transshipment points to the car dealers all over the world.

Medium sized companies with plants in one continent, e.g. in Europe, need a fixed continental network, e.g. a *Euro-logistic network*, combined with a flexible international network in the other parts of the world.

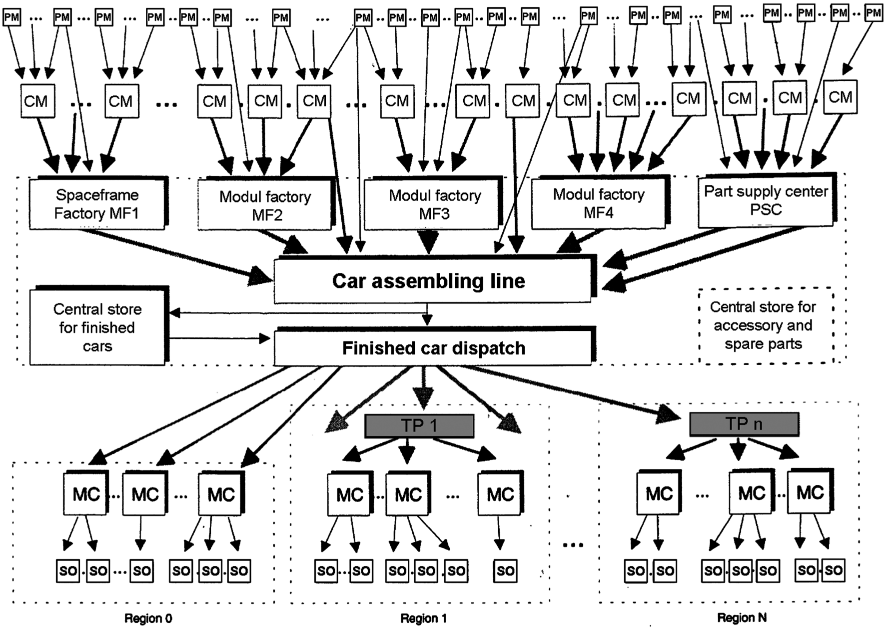

Fig. 1.15 Logistic network of a car manufacturer (SmartCar)

PM: parts manufacturer (3rd tier) CM: component manufacturer (2nd tier)
MF: module factory (1st tier) CA: car assembly;
CW: central warehouse for parts TP: transshipment points
MC: market center SO: sales outlet

Also *global logistic service providers*, such as international freight forwarders, airlines and shipping lines, operate with combined logistic networks. They connect their own fixed global network with flexible local networks of contract partners or *subcontractors*. By this means they can offer a complete logistic network that covers the whole globe.

1.9.3 Tasks of Network Management

Logistics is unlimited. Therefore, it is necessary to define borders, links and interfaces, to set goals within the limited network, to decide on the objectives, to allocate the execution of the orders and to control the results. These are the tasks of *network management*.

Who has to solve logistic problems must look beyond the borders of the own logistic network. In order to avoid barriers, a logistician must know at least the first stages of the *downstream chains* of the customers and the last stages of the *upstream chains* of the suppliers. Barriers have to be transformed into connections that enable uninterrupted flows of goods and information.

Company logistics includes *supply chain management* and *network management*. Depending on the corporate objectives and the logistic network, the general *tasks of company logistics* are:

planning and forecasting of demand
development of strategies
design of network structure and standard supply chains
planning and implementation of own logistic systems (1.13)
synchronization and adjustment of interfaces and links
scheduling of orders and stocks
logistic controlling and consulting

The special tasks of logistics differ from company to company. In case of logistics being a *core competency*, company logistics should be organized as independent corporate unit on the same level as production, finance, administration, purchasing, and sales (see *Sect. 2.9*). Temporary tasks, such as development of strategies, configuration of the network or planning of a project, may be partly delegated to an experienced *consultant*.

1.9.4 Future Tasks of Logistics

After industrialization of production and manufacturing, which has started in the early 19th century, is widely finished today, it is the challenge for the 21st century to industrialize the performance processes.

The implementation of fixed transport networks and the building of large logistic centers will come to an end in the next future. In the densely populated and highly industrialized countries space for new roads, railroads, airports and logistic operations becomes scarce. Therefore, the goal of the future is to manage *flexible networks* by using the existing limited resources in the best possible way.

Logistic research should investigate the necessary *legal frame conditions* and develop suitable *strategies* for this challenge. This research is an important field of activity for *analytical-normative logistics* as well as for international institutions such as the EU and the OECD (see *Chap. 23*).

1.10 Task of Logisticians

The word *logistics* has three basically different meanings:

- *Practitioners* regard logistics as the activities necessary to set up and operate transport, storage, traffic and handling systems and networks.
- *Planners* understand logistics as the design, dimensioning and optimization of logistic networks, processes and systems.
- *Theorists* see logistics as investigation of practices, search for principles, examination of options, and development of strategies, algorithms and rules for planning, set up and operation of systems and networks.

Many people are not aware of these differences (Murphy 2004). However, without distinction between the different meanings of the term “logistics”, there is a risk of contradictions and drawing pointless conclusions (Popper 1971). This explains many misunderstandings and contradictions between *logisticians*.

Fig. 1.16 Tasks of logisticians and relations and tensions between theory, implementation and practice in logistics

The more logistics is expanding and specializing, theory, planning and practice diverge. This development can be observed in other disciplines too. *Figure 1.16* shows the tasks, responsibilities and links of the three fields of logistics.

According to the different tasks of logistics, there are *strategic logisticians* or *theoreticians*, *implementing logisticians* or *planners* and *operative logisticians* or *practitioners*, who respectively focus on theory, implementation or business practice. From the most competent and successful members of these groups, come the *logistic managers* or *supply chain managers*. Managers set the goals, decide upon suggested solutions and determine the course for new developments and conceptions.

Conditions for the success of strategic, implementing and operative logisticians are mutual respect, knowledge of the objectives and contributions of the others, and a joint orientation towards practical benefits for customers, company and society.

1.10.1 Strategic Logisticians and Theorists

The objective of strategic and theoretical logisticians is to *contribute to practical use* by analysis of the basic principles of logistics and by developing innovative logistic concepts and strategies. This group consists of academics at institutes and universities and of consultants, strategists, organizers and systems analysts.

Prerequisites for a successful strategic logistician are analytical thinking, openness for new ideas, creativity and judgment. *Analytical-normative logistics* requires knowledge of the methods and strategies of logistics and business administration, sufficient command of arithmetic, algebra, probability theory and statistics and some know how in *operations research*. A further necessity is to know the realities and requirements of the daily business.

Many theorists are *generalists*. They tend to set up tautological terms and definitions, to develop models out of touch with reality and to make considerations with little relation to practice. Logistics as *applied science* is justified by its applicability in practice. Hence, the measure for strategic logisticians is their contribution to practical use.

Whoever asks "What is logistics?" or "What do we mean by Supply Chain Management?" will produce a number of new terms but will not create practical benefit. Only those who asks "What are the objectives and tasks of logistics?" and "How can we solve this problem?" will come to beneficial answers and create the necessary terminology for the specific purpose (Popper 1971).

Some theorists follow the principle "why look for a simple solution if a complex one is possible?" This group wants to use a smart algorithm, to test a new OR-technique, to do *chaos research* or to apply *complexity theory* even though no relevant practical improvements can be achieved. Instead, the challenges for theorists are to understand a complex logistic system, to find out its rules and to make the system controllable (see also *Sect. 10.5.5*) (Popper 1971).

1.10.2 Implementing Logisticians and Planners

Implementing logisticians and planners have the objective to develop, construct, plan, organize, program, and set up machines, sites, systems and networks that *bring about practical benefit*.

First of all, the planners and project managers of companies and general contractors for storage, conveyor, transport and logistic systems belong to this group. Others are the developers, planners, programmers and systems engineers working for the suppliers of machines, equipment, vehicles, control systems and software.

Prerequisites to success for an implementing logistician are constructive thinking, organizational competencies and a profound knowledge of the possible solutions, the specific circumstances of the project and the necessities of operative logistics.

Planners and implementing logisticians tend towards specialization and over-engineered solutions. Their position is often quite thankless. In case of success, it was due to the initiative of the client or his consultant. In case of failure, it was the planner's or the executing company's fault.

1.10.3 Operative Logisticians and Practitioners

Operative logisticians and practitioners have the objective to *generate permanent benefits* by putting the best solution into action. Schedulers, plant managers, operators and users of logistic centers and logistic systems belong to this group. Most of them work for *logistic service providers*.

Also *logistic managers* have to be in many respects practical logisticians. They manage logistic operations or a logistic network and take care for the sustainable competitive advantage of the company.

Operative logisticians need the ability to think practically. They have to have a solid knowledge of the techniques and capacities of their equipment, sites and systems. Operative logisticians in management position must be capable to organize processes and to decide under uncertainty.

Practitioners schedule incoming orders, operate computers and lead business plans to success. Not all plans survive the contact with reality, not all software is suitable in practice. The schedulers make decisions, on which the daily profit or loss of orders and in the long run of the whole business depends. Therefore, they should be well educated and trained (Gardiner 2005/2002; Murphy 2004). To keep them motivated, their work and contribution has to be appreciated by the management (see *Sect. 24.3.2*).

Practitioners that have been working only in one company or one specific industry for a long time tend to get routine-blinded. This often leads to arrogance towards theorists who vice-verse are inclined to look condescendingly at practitioners.

1.10.4 Specialists and Generalists

Most results, options and solutions of logistics are quite trivial or straightforward. However, they are multifaceted and numerous. Therefore, if not proceeding systematically, *complexity* causes confusion.

In logistics the wheel is often reinvented and old wine is sold in new bottles. This happens to beginners when they start to think about the causes, effects and possibilities of logistics. However, also some professionals tend to reinvent the wheel.

Specialists are experts in a narrow area. They know all about their specific field. However, they also recognize the limits and barriers. Specialists think in construction and technology, in experience and examples, in programs and computers or in profit and cash flow. Due to many reservations, some specialists are incapable of making decisions. They lose the overview and tend to overestimate partial aspects. Who is lost in the thicket of numbers and the multitude of technical details, does not see the wood for the trees and fails to find the best solution.

Generalists are familiar with many subjects. They keep an eye on a very broad field, recognize correlations and think in systems. Generalists are often more decisive and willing to take risks than specialists. Due to a lack of deeper knowledge and limited know-how, generalists tend to underestimate problems, do not see realization barriers and are unaware of innovative solutions. Some generalists replace know-how by belief. For instance, by uncritical belief in ISO-regulations they become unrealistic "ISOterics".

Without knowing the principles and realities and without keeping critical details in mind, there is the danger to fantasize. *Visionaries* tend to develop "intergalactic" solutions of no practical benefit. Such detached generalists consider a high number of simple relations as "highly complex". They call the network of relations between suppliers, customers and service providers "virtual enterprise" or reinvent the work-shop production by calling it "fractal factory".

Other theorists and strategists consider only one aspect of logistics: *Just in Time, Kanban, Outsourcing, Benchmarking, Supply Chain Management, RFID*, *e-Logistics* or *Green Logistics*. Each of these fancy terms claims to solve just about all tasks. However, logistics has many facets and should be considered under all relevant aspects.

Good logisticians are specialists in one or two fields and generalists in all other areas of importance for logistics. They follow the *hawk principle*:

- The logistician stays above theory and practice and observes with sharp eyes structures, processes and connections. If a certain field shows progress, the view is focused, good solutions are assessed, details analyzed, and useful ideas are captured from the lowland of theory and practice.

The permanent change between *top-down* to *bottom-up* and vice verse widens the competencies. By this process, the logistician gains further abilities to solve real problems.

Who has no distance, does not see the whole. Who only focuses on details, can not understand the relations. A system is more than the sum of its elements, but the function of the total system can depend on one element only (Lenk/Ropohl 1978). This holds especially for *bottlenecks* that arise in practice everywhere, but are not noticed immediately (Goldratt 2002; Gudehus 1975/I). Bottlenecks are decisive for the capability and efficiency of performance, production and logistic systems, and therefore are a central topic in this book.

1.10.5 Theory and Practice

Apart from the contributions of *Operations Research*, logistics is in many areas a *skill* based on experiences and experiments. Most practical innovations in logistics are still found by *trial and error*. Some practitioners emphasize this proudly. Faced with a theoretically based proposal, they object: "That might be right in theory but is of no use in practice".

More than 200 years ago, the German philosopher *Immanuel Kant* wrote an essay about this objection (Kant 1793). He criticized theoreticians, who never will become practical, and told the practitioners: "Nobody can disregard theory without being an ignorant in his field".

Tensions have always existed between theory and practice and will remain in future. For logistics, they are reflected in the *tension triangle of logistics* shown in *Fig. 1.16*. Without these tensions, neither progress in practice and nor discoveries in theory are possible.

One goal of this book is to develop a practice-oriented *theory of logistics* (Morgenstern 1955). Without unnecessary complexity and abstractness, it should help to a better understanding. Analytical-normative logistics offers *rules* for solving problems, develops *methods* for attaining logistic objectives and designs *strategies* for the planning and operation of logistic systems.

Kant also has said: “nothing is more practical than a good theory”. Applied to logistics and business practice, follows:

► Nothing is more useful than a good strategy.

Hence, the development of strategies of practical use is another central focus of this book.

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