2 Planning Basis

This chapter describes a strategically justified planning basis which can be regarded as a guideline for the planning team. First, based on the factors that impact a plant and that were outlined in Chap. 1, the production strategy needs to be determined. This step, which is the task of corporate planning, includes identifying products and business processes that are to be manufactured or executed in the factory. Within a factory, generally speaking, the order fulfillment with its sub-processes stands in the foreground while the products and business processes typically determine the location and factory areas that are to be designed. The other major components of the planning basis include decisions about the type of factory from the customers' perspective, the position of the factory in the supply chain and possibly the integration of the factory into a production network.

2.1 Production Strategies

A factory is not operated for its own sake, rather it is one of a number of instruments a production enterprise utilizes to realize their business strategy. Up until the 1970s, the necessity of operating the factory was never a question; rather the priority was safeguarding employment. Nowadays, discussions primarily focus on which role in-house production should play in the competition for markets and how the enterprise's financial resources should be allocated. The possibilities of global procurement and co-operations as well as developments in technology and logistics have created new degrees of freedom for configuring and positioning the own production. These should be utilized against the background of a well thought out competitive strategy for the entire company, thus ensuring its long term economic viability.

According to M.E. Porter, a competitive strategy includes in particular:

- concentrating on selected market segments,
- differentiating the products and services in comparison to the competition as well as
- gaining a comprehensive cost leadership [Por98].

The competitive strengths and determinants that should be analyzed and evaluated in this respect are briefly summarized into five so-called 'forces' in Fig. 2.1.

The starting point is the number of competitors and the intensity of the rivalry among the existing firms in the branch. The latter is determined for example by over capacities, brand identity and exit barriers. Following that new entrants and their entry barriers in the branch are analyzed. The third force concerns buyers and their bargaining power and sensitivity to prices, while the fourth takes into consideration possible substitute products or services and the danger of one's own product being replaced. Finally, the fifth force focuses on the bargaining power of suppliers.

An important approach within this context involves evaluating effectiveness ("doing the right thing") and efficiency ("doing things right")

H.-P. Wiendahl et al., *Handbook Factory Planning and Design*,
DOI 10.1007/978-3-662-46391-8_2,

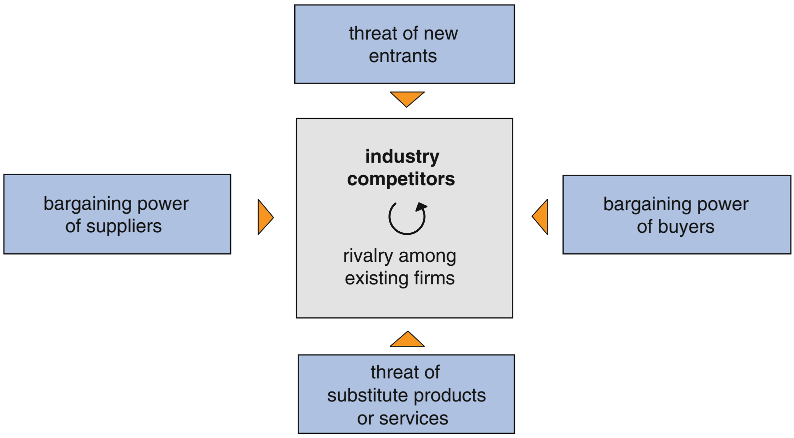

Fig. 2.1 Forces driving industry competition (per M.E. Porter). © IFA D3436_Wd_B

with the aid of the 'Balanced Scorecard'. The Balanced Scorecard supports the multi-dimensional strategic planning and control of an enterprise or division. Based on a suggestion from Kaplan and Norton [Kap96], starting with a superordinate vision and strategy four perspectives are developed (see Fig. 2.2). Strategic goals are to be formulated for each perspective, from which operative targets and actions are derived; compliance with these is then monitored based on specific parameters.

The *financial perspective* examines whether a selected or implemented strategy improves the business results or not from the perspective of the

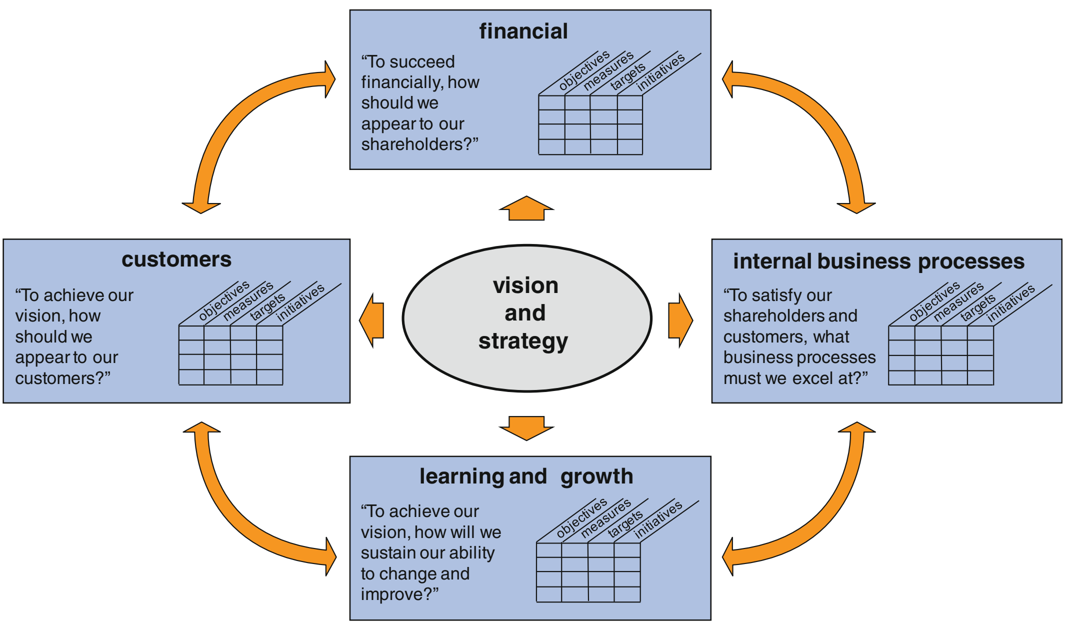

Fig. 2.2 Basic concept of the balanced scorecard (per Kaplan and Norton). © IFA G8889SW_B

shareholders. Based on the analysis objectives, variables, targets and measures can be derived. If we consider the production for example, this would concern the share of in-house production, the resources that should be implemented and the location.

In consideration of the factory itself, the *customer perspective* poses the question of whether or not the factory fulfills the service characteristics that the market demands e.g., delivery time, delivery reliability and the quality of the product. However, general objectives such as customer satisfaction and customer loyalty are also taken into consideration here as drivers for the company's success. Corresponding measures might then include focused sub-factories close to the customer or re-designing the corporate identity from the bottom-up.

The *perspective from the internal business processes* prioritizes the structures and processes that play a decisive role in satisfying customers' wishes and whose improvement is perceived by customers. From the factory view this could for example include, internal throughput times, the possibility of making late decisions about variants or implementing a product quality concept that saves customers from having to inspect goods upon receipt.

With the *learning and growth perspective*, the importance of the ongoing and progressive development of products and methods is emphasized. From the view of production this concerns for example, continually improving production technology, introducing team work or developing uninterrupted logistic chains from the in-house production up to and including the customer.

One of the noteworthy aspects about the Balanced Scorecard is that in comparison to traditional methods, such as the Return on Investment (ROI) concept and Shareholder Value approach, it does not draw one-sidedly on financial and to some degree strongly historical based parameters for making decisions. Rather, the view is oriented more equally on the customer, competition and internal factors that are not only difficult to measure (e.g., the ability to innovate and learn) but also increasingly significant for the success of a business in a turbulent market. The concept thus offers a flexible framework for developing each of the enterprise specific strategies, which is in turn indispensable especially with regards to the future role of the factory.

2.2 Factory Strategies

When planning a factory, it is essential to have knowledge about the part of the business strategy pertaining to the market and the production; without this information the orientation on cost related aspects dominates too easily. Figure 2.3 depicts the key strategic elements of the planning basis for a factory, which are subject to three premises: First, they have to be *sustainable* in an economical, ecological and societal respect and thus not aimed at short term success. Second, the call to be *innovative* arises from the dynamic environment and applies not only to products, but also and especially to the production and administrative processes. Third and lastly, changeability is imperative—not just for the factory, but certainly for it in particular.

Business areas developed from visions and models form the core of the strategic basis. They designate a distinct external market which has clearly demarcated competitors and is closely aligned with the enterprise's philosophy, values and culture. Every business area is defined by a market offer and a market segment, described by the types of customers, distribution channels or geographical regions [Gau99]. Determining the sales region according to revenue and the regional market share is particularly important for strategically positioning the factory. The sales volume on the one hand and the local competitive environment on the other hand, result from there and provide the starting point for decisions about where to locate the factory and the scale of production.

2.3 Market Offer

The products and services available in market segments are defined for every business sector and are summed up together under the term

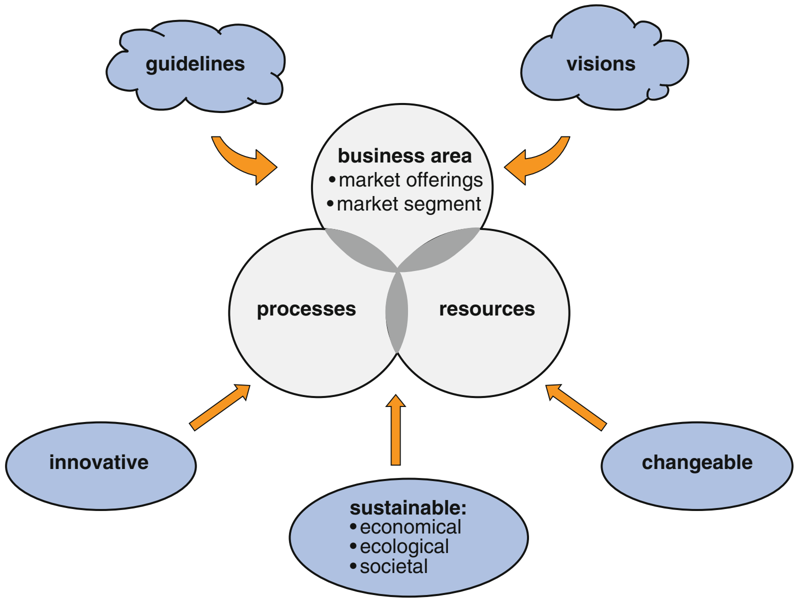

Fig. 2.3 Strategic basis for planning and designing a factory. © IFA G8891SW_B

market offer [Gau99]. This market offer requires *processes* that the enterprise's potential should yield. These are then generally divided into management, business and support processes. The business processes—to the extent that they concern the factory—are value-adding and consist of production engineering processes, material flow processes as well as information and communication processes. They require *resources* which basically consist of people, equipment and capital.

The market offer yielded by the enterprise can be considered from the perspective of logistics as well as according to the type of market service. With regards to logistics, the classification system developed by Siemens for their market offer is practical for this purpose; it defines four types of businesses according to the point in time at which the final product is defined and where the value is added (see Fig. 2.4) [Faß00].

The business types include consumer oriented products, systems for industry equipment, large projects related to plant construction and after-sale services. Each poses clearly different demands on the factory and its logistics.

Products are ready-to-use consumer goods usually meant for the end user such as household appliances, entertainment electronics, communication technology etc., which, for the most part, are self-produced. They are developed independent of specific orders and factors for success include, extremely short delivery times and a high service level due to good inventory management as well as an efficient, frequently world-wide distribution system.

Systems consist of custom designed configurations of—as much as possible standardized—hardware and software elements, whose function-defining modules are manufactured in-house and completed with purchased system components. The development and logistics cycles are thus only partially decoupled. Here, factors for success include the ability to quickly configure standard and procured components, managing order-specific supplies with high delivery reliability, directly supplying complete systems that have already been tested and then immediately installing and putting them into operation.

Plant related businesses mainly consist of engineering i.e., the technical design and planning of custom-made large plants, such as steel mills, paper mills or power stations. Products here cannot be made-to-stock due to the unique character of each; engineering and logistics cycles are therefore coupled for each order. Since components produced in-house play a small role,

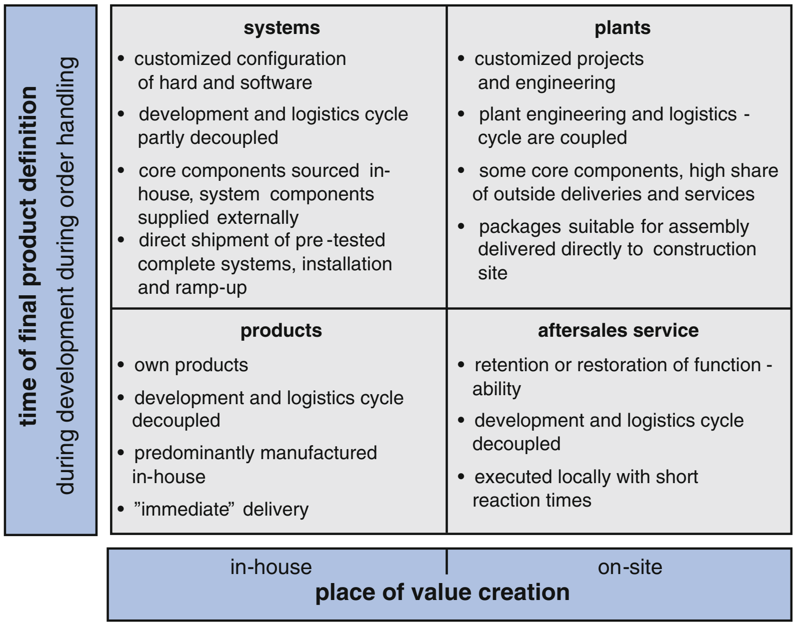

Fig. 2.4 Logistical business types (Siemens). © IFA G8908SW_Wd_B

success factors include professional project management, controlling and coordinating the numerous customized deliveries and services that are predominantly supplied externally as well as punctually delivering the assembly-ready packages to the construction site which represents the location of the greatest value-adding processes.

The fourth type of business, *services*, refers only to the after-sales services of a product, system or plant. They serve to maintain their functionality (e.g., via regular inspection and maintenance) or in the case of disruptions, to restore it. The development of these services in the form of maintenance plans, repair kits, spare parts etc. is temporally decoupled from their provision in the logistics cycle. Factors for success here include the ability to react quickly and provide fast information while maintaining a minimal store of spare parts as well deploying and supervising technicians with a high rate of jobs completed in only one visit.

With regards to how markets are served, there are two known extremes of market offers, which apply mainly for products. On the one hand, there are mass programs, with which a cost leadership is pursued by increasing quantities of standardized outputs i.e., so-called 'economies of scale'. On the other hand, there is the 'economies of scope' strategy which strives to maximize the utility by focusing on multiple products for special groups of customers. In between these two there are strategies aimed at individualized mass production based on modular systems and flexible manufacturing methods. Customers then receive products that are to a large extent finely tuned to meet their needs, comprised of different quantities and variants of standardized parts and components that are quickly and flexibly assembled.

In addition, the strategy of supplementing products with services and selling the product utility instead of just the product is being pursued increasingly, especially in highly industrialized countries. It has been shown that customized products with value-adding services open up very promising potential in regards to global competition.

In Fig. 2.5, the basic dimensions of a competitive market offering are outlined. The key idea is that the market offer is oriented on the customer's value-adding chain. Based on a product which has a large benefit for a customer, the enterprise considers how they can attain long term customer loyalty by integrating services into

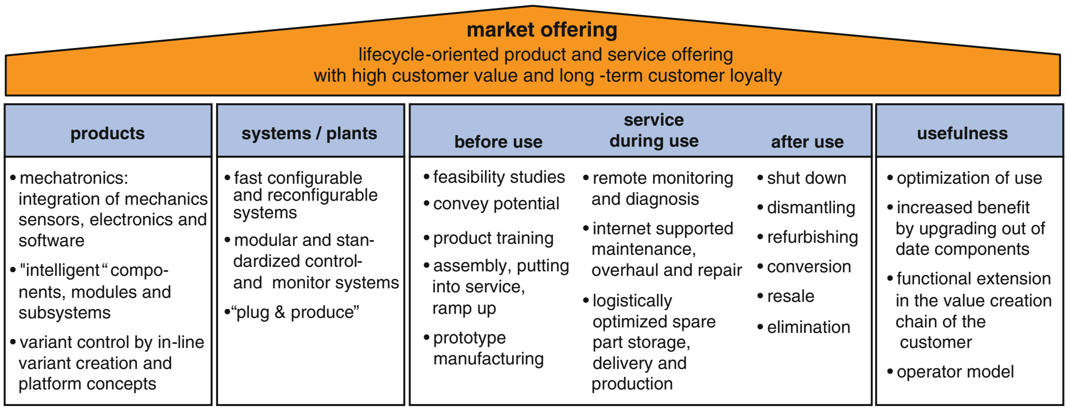

Fig. 2.5 Dimensions of market offerings. © IFA G8899SW_B

the product above and beyond the entire lifecycle of the product. This leads to four categories of market offers, namely products, system/plants, services and usefulness, which can now be considered from the view of design and production.

With *products* it can be seen that 'mechatronics', i.e., combining mechanical parts and electronic components together with integrated software, is emerging increasingly. The latter ranges from sensor technology (for recognizing operating states) to electronics for everything from product application and control up to and including corresponding software. In the meantime, in many engineering products the portion of production costs due to mechanics, electronics and software is equally large.

In order to quickly configure and reconfigure the products to the changing needs in the lifecycle of the customer products, efforts are being made to develop so-called 'intelligent components', modules and sub-systems that are equipped with sensor and control technologies and can communicate with other devices. Not only do they considerably decrease the scope of the higher level control, but they also monitor themselves, allow their functionality to be tested during production before they are integrated and thus greatly reduce the effort involved in the final assembly. Module and platform concepts such as this allow a wide diversity of variants especially when variants can be formed by configuring software.

Finally, it can be determined that for many products, especially in the capital goods industry, there is a trend towards businesses for *systems and plants*. The customer frequently wants to receive so-called 'plug and produce' systems (e.g., a manufacturing system) or plants (e.g., packing plant) and expects a service packet that includes everything from engineering, delivery, commissioning and staff training up until the ensured yield is attained as well as optimization during its use. Depending on their value and complexity, the system or plant requires an extensive range of additional services to be operated. More and more often, the users are no longer able to perform these services themselves because they no longer have the skills required. Whereas previously, factories had their own planning, maintenance and repair departments, nowadays these tasks have been largely transferred to specialized service providers. Their services are then divided into three phases: before, during and after use of the system.

The *service* begins in the pre-use phase with feasibility studies and is supplemented with offers to illustrate the potential of the proposed investment. The latter can include for example, sample parts, delivering so-called 'pilot series' or educating design engineers in using a new technology. Thus, for example, a known producer of machines for processing sheet metal offers a workshop in which the technical and economic advantages of sheet metal construction in comparison to welding and casting are methodically conveyed to the designers based on sample parts. Afterwards, the participants have the opportunity to design and produce a prototype of a customized part and subsequently to economically evaluate it. Further traditional services in the pre-use phase concern the product training of later users, assembly, commissioning and start-up, especially of systems and plants up to the agreed upon capacity.

The second type of service refers to the operating phase and is shaped by the quickly developing possibilities of information and communication technology. The previously mentioned intelligent product components and systems meanwhile allow products to be remotely monitored and diagnosed by suppliers, whether in regular maintenance cycles or when there are malfunctions. In many cases an internet based maintenance and repair service can be developed from this, allowing the customer to remotely access services from the manufacturers. This could for example be special repair manuals, linked with digital disassembly and re-assembly drawings.

It is also possible for the product supplier to design their on-site customer service more quickly and more productively by giving their service employees access to in-house product data and repair instructions remotely. Finally, for the spare parts service, new possibilities arise by using the internet to optimize their storage, delivery and production.

With the quicker follow-up of products, the final phase of the product life for products, systems and plants gains significance. Previously their shutting down, dismantling and disposal was a rather burdensome side-issue. Increased awareness about environmental protection and stricter legislation requires this phase to be professionally considered as well in the sense of waste recycling and management. Thus offers are being developed to properly dismantle plants down again to a green field and refurbish them for the purpose of reuse and resale. When this is not possible or economical, it then comes down to recycling and/or disposing of them harmlessly (see Sect. 2.7).

Another approach goes even farther than just offering services during the three use phases to the extent that it is not even concerned with producing a defined material or immaterial output. Rather it focuses on selling the purpose of the output and thus on making the *utilization* of a product, system or plant a product itself. With that a particularly close, almost symbiotic customer relationship is achieved. This fourth dimension of the market offer is generally yielded by the manufacturers, to limit the financial risk, frequently in the form of a spin-off firm.

One possibility is to combine single services into a service package with the aim of ensuring or increasing the utilization of the product for the customer's value-adding process. This can, for example, affect the availability of a 24-hour server center, the yield of a production machine per shift or the operating costs of a pumping station. This service is created by extending the remote maintenance offer by optimizing operating parameters and the spare-parts stock. Yet another service might be increasing the utilization of a system by exchanging outdated components, e.g., electronic control panels. Finally, it is also possible to extend the functionality of a supplied product in the value-adding chain of the customer e.g., by installing an automatic loading system for a production plant as a replacement for a manual solution.

The most extensive example of this utilization-oriented market offer is the so-called 'BOT model' (Build-Operate-Transfer model). In this case, the manufacturer of the plant or an external service provider operates the production plant and only delivers finished products to a consumer, frequently directly to the site of the customer's plant.

The factory for manufacturing the Smart Car in Hambach, France is a known example of this. There, 15 suppliers contribute 80 % of the value-adding to the finished product (see also Fig. 2.14). One of the suppliers, Eisenmann, supplies and operates the painting plant there. They are paid for every car body that is painted [Bar98].

It was anticipated that BOT models would be very important in the future because they reduce the complexity of the user's production as well as decrease their investment risk and costs. At the same time, they open up a long-term customer relationship for the producer who has the know-how. Nevertheless, the operator is also directly

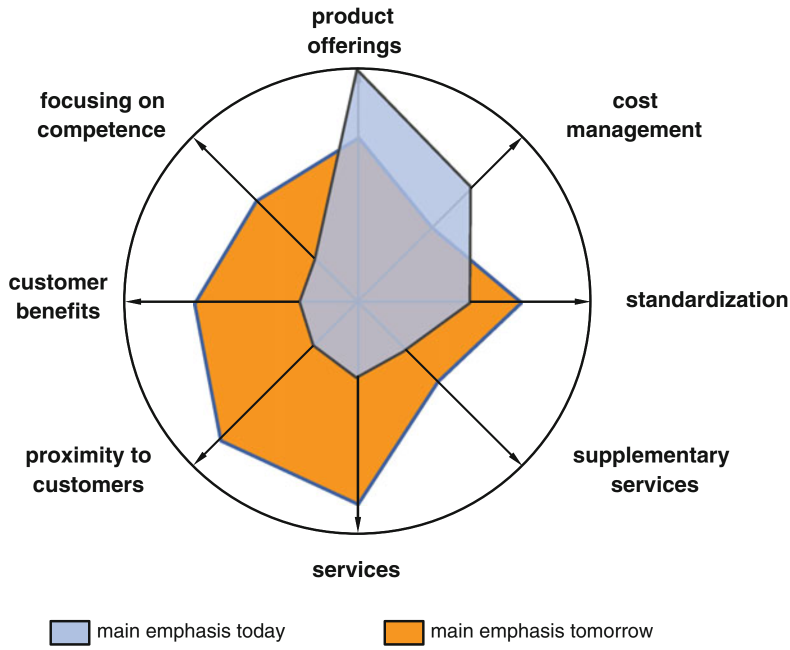

Fig. 2.6 Future emphases for production enterprises (per Boutellier, Schuh, Seghezzi). © IFA G8915SW_B

impacted by their success or lack of success in the market and thus correspondingly takes on the risks. Usually, a special core business firm is established in order to financially decouple them. Against expectation the model has not wide spread to industry mainly because of the financial risk for the plant deliverer.

If we are to summarize the information about market offers, it can be seen that the dominating model for all of the business' activities is clearly oriented on the customer. Moreover, it is dependent on offering customers individual solutions in their value-adding chain, taking on calculable customer risks in one's own value-adding chain and including the customer in designing and creating the solution [Bou97].

With that (from the perspective of the market offer) a number of future emphases for production enterprises can be identified (see Fig. 2.6).

In order to escape the dilemma between pricing pressure and increasing customer wishes, paid product-integrated services should be extended and traditional product outputs reduced to core components. This requires standardizing individual services and products, developing more intensive value-adding supplementary services and focusing on key competencies. In doing so the pressure on managing costs decreases since the new market offers are paid for. As a result, the customer benefit and proximity to the customer increases on the whole [Bou97].

2.4 Business Processes

As already mentioned, the offerings defined in the business sectors are to be yielded through *processes*. As Gausemeier wrote: "A process is a number of activities aimed at yielding a result which is of value to the customer" [Gau99]. With this, Gausemeier expressed the break from functional organization (characterized by splitting the work down into continually smaller units). Processes are linked to process chains which can be identified as either main business processes or supplementary processes.

Figure 2.7 depicts a breakdown of the business processes which are well-established for production enterprises. The *main business processes* follow the lifecycle of the market offering. The 'market opening' process is responsible for

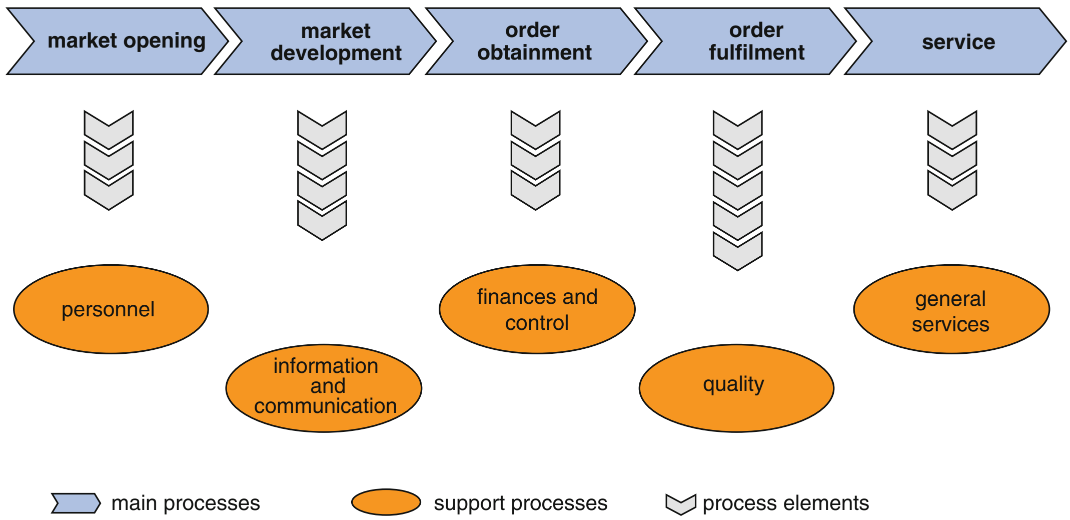

Fig. 2.7 Business processes. © IFA G8902SW_B

defining the market offer in form of a specification based on the business sector strategy. From that, a functional product, suitable for series, emerges in the 'market development' process. This product is then offered and sold to customers during the 'order obtainment' phase, whereby the technical, logistical and economic feasibility has to be ensured when signing the contract. The 'order fulfillment' phase summarizes the processes from order confirmation to shipment including the necessary procurement procedures. Once the customer has begun using the product, the 'service' phase (as described above) begins. One of the key attributes of these main processes is that one person (whether that be a supervisor, manager or a team leader) is completely responsible for the results and resources.

The *support processes* 'personnel', 'finances and control', 'quality management' (including planning, monitoring and testing), 'information and communication' as well as 'general services' (which ranges from the building maintenance up to site security) serve to supplement the main processes. They have to sell their services to the owner of the main processes at the agreed upon price and are thus competing against external service providers.

2.5 Aspects of Factory Design

The main business process that is essential to the factory is the *order fulfillment*. The sub-processes that need to be yielded here include the order input, product design (as far as the order specifications require it), job prep, sourcing of raw materials and purchased parts, part manufacturing, assembly, testing, packaging and shipping as well as the related quality checks and job control. These sub-processes are to be generated by factory resources, which are summarized together under the headings technology, organization and employees in Fig. 2.8. They form, so to speak, the pillars of the factory that are built upon a site and its buildings. A convincing market offer, however, is not just created from material and human resources, but rather is also determined by aspects of the enterprises culture and sustainability, which result both from the enterprise's comprehensive vision and from the local conditions.

Figure 2.8 identifies the key aspects of factory design that we will address in this book with regards to how they can be structured and dimensioned particularly with respect to changeability. Cost and feasibility considerations

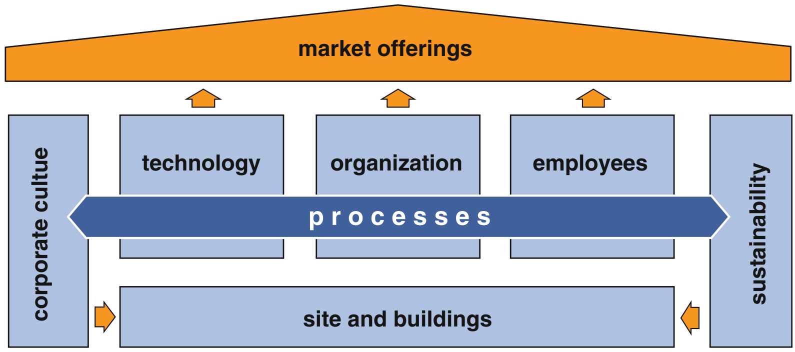

Fig. 2.8 Aspects of factory design. © IFA G8900SW_B

are components of the planning process and are discussed there. The order processing influences the factory layout to a far greater degree than any of the other remaining main processes or support processes mentioned in Fig. 2.7. These other processes mainly require resources such as office space, personnel and infrastructure, which are organized during the general planning.

All of the enterprise's processes and functions have to be oriented though on customer demands, market offers and a guiding vision that is developed in consideration of changeability.

2.6 Manufacturing Location and Factory

In view of our discussion about developing a production concept there is still the question in which scope and with what strategic orientation the individual enterprise wants to produce its products. The decision about the geographic location of the production is then made accordingly. When doing so, two different perspectives need to be distinguished; an external and an internal (see Fig. 2.9).

The term *manufacturing location* represents the external perspective. Within the scope of developing business sectors, market offers and necessary processes, a suitable manufacturing location has to be selected from a global perspective. These provide a market segment with specific goods and services related to the selected business sector in view of its economic and logistics criteria. In a second step, most often on a closed site, the factory is designed in the sense of an internal perspective of the manufacturing location. The *factory* is thus a local bundling of the primary production factors (personnel, resources, buildings and materials) as well as the necessary knowledge, qualifications and capital.

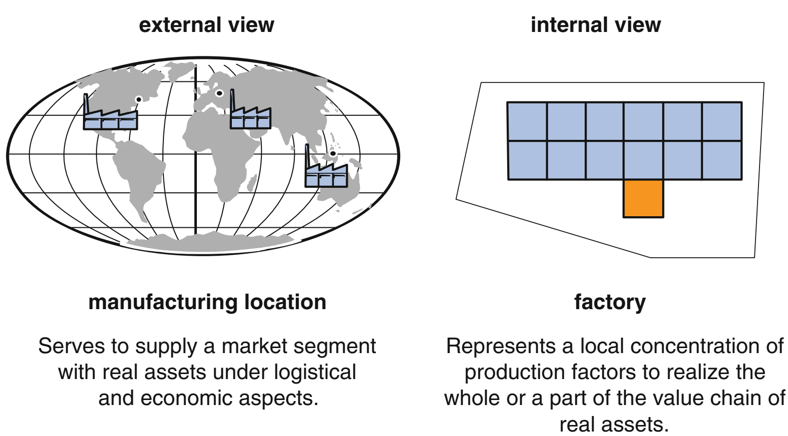

Fig. 2.9 Comparison of manufacturing location and factory. © IFA G9630SW_B

In the form of processes, these factors realize the parts of the value chain necessary for delivering the goods required by the manufacturing location. The term 'value chain' in comparison to value-adding chain also includes the activities such as storage, transportation, testing etc., that are inevitable due to the selected manufacturing principle but that do not add value.

Within the factory, a number of products for different business sectors and different proportions of the value chain can be manufactured. As already mentioned, due to the clear responsibilities for costs, quality and delivery capability the aim here is to operate sub-factories (often referred to as 'mini-factories', 'business units' etc.) which are demarcated as much as possible both spatially as well as organizationally. These sub-factories then only use a common infrastructure with regards to their energy supply, data processing, social facilities etc.

2.7 Morphology of Factory Types

Based on these considerations, we can now develop a morphology of factory types that combines four attribute levels. These originate from specific views of a factory and are primarily determined by the production strategy (see Fig. 2.10).

The first perspective is concerned with the *position of the enterprise* in the supply chain between the raw material suppliers and the end consumer (see Fig. 2.11). An extreme case is an enterprise that manufactures the raw goods required for its product itself as well as the end product with all of its interim stages before delivering it directly to the end user. This was the case at the start of the industrial age in North American automobile manufacturers. As a result of continually greater differentiation and specialization this is no longer economically and logistically feasible. Thus in the meantime, suppliers for raw materials, parts, components, modules, sub-systems and end products have developed. Each of these covers a stage of interim products and delivers them to a customer. Here, a customer can be a company that further processes it, a middleman or an end customer.

The second perspective is concerned with *how the customer perceives the factory*, that is, what its most predominant strategic attribute is in the sense of positioning themselves amongst their competitors. Six different forms can be identified here (see Fig. 2.12).

The *high tech factory* is characterized by products that are on the leading edge of technology in the world market e.g., with regards to their function, level of performance, lifecycle costs, availability etc. The manufacturing and assembly processes are operating close to their

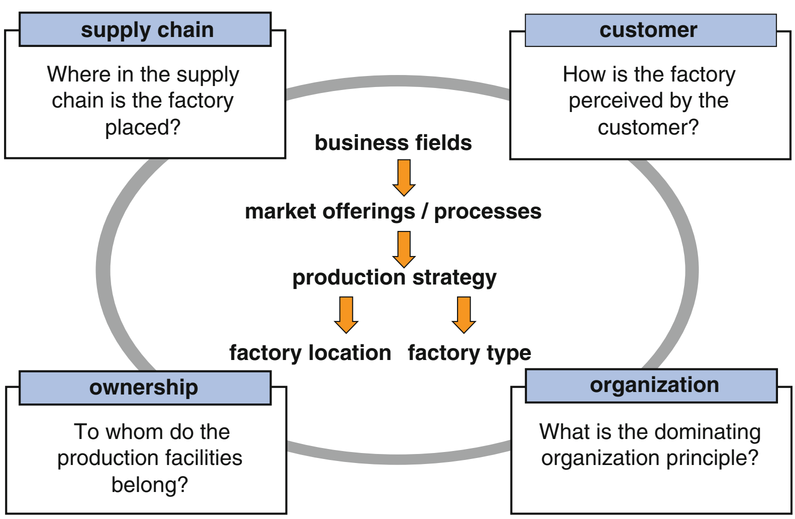

Fig. 2.10 Perspectives for developing factory types. © IFA G9637SW_B

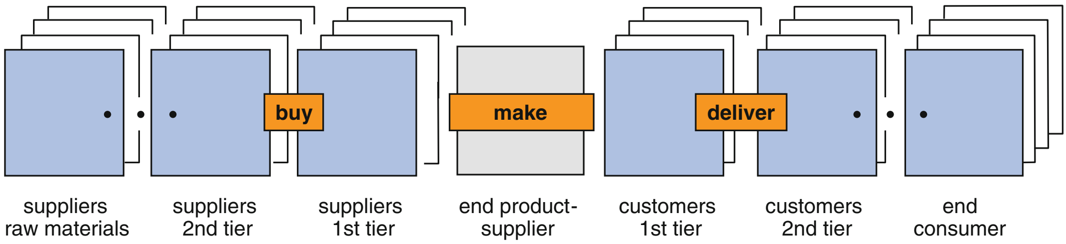

Fig. 2.11 Components of a supply chain. © IFA G9638SW_B

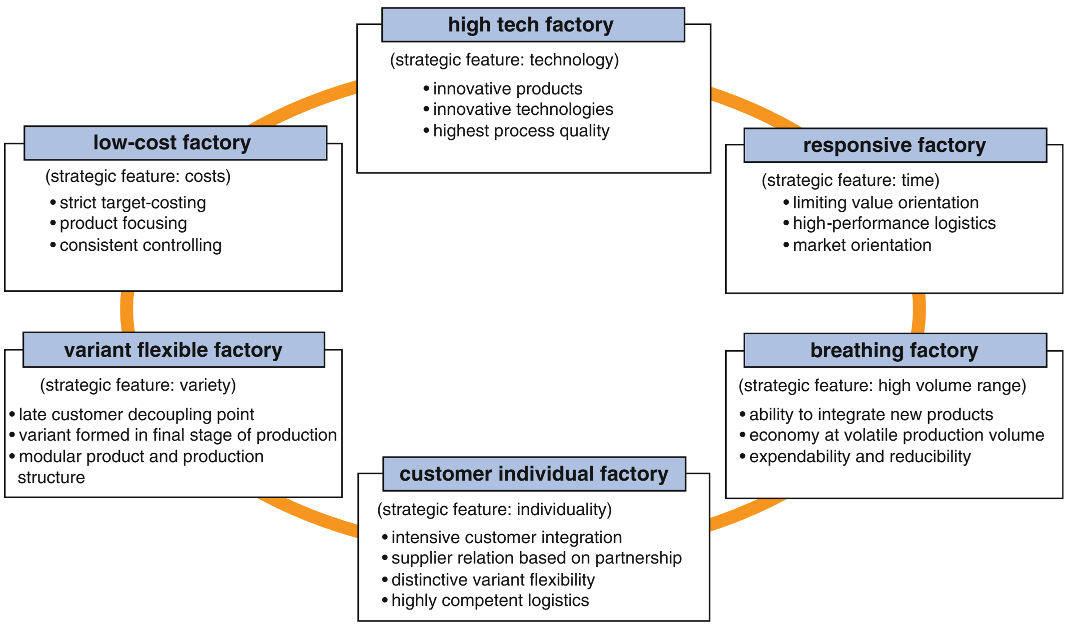

Fig. 2.12 Types of factories from a customer's perspective. © IFA G8629SW_B

natural limits (see Sect. 3.3) usually with self-developed technologies and with the highest process quality. The factory, both inside and outside, reflects the extraordinary demands set by the company on high-end technology. Since these are the innovators, premium prices are targeted and costs, delivery times and controlling variants do not play a large role.

The *responsive factory* focuses on the time factor. It is characterized by highly efficient logistics, which is also oriented on limits—in this case on throughput times. Since the products do not lay claim to any leading technology, their competitive edge lies in products being quickly available to customers. Orders are often inserted into the production directly by the customer or distributor.

In the *breathing factory* the focus is on economically manufacturing products with seasonally dependent sales fluctuations (e.g., household appliance and sporting goods industries) with largely varying production quantities. This is achieved with a comparably low degree of automation, very flexible work hours, and cross-trained employees. Consequently, new products can be quickly integrated and the factory output can be rapidly increased or decreased.

If the product spectrum is marked by a large number of variants, in the sense of a customized market supply, the *variant-flexible factory* should be pursued. It is characterized by modular structures as well as manufacturing technologies that allow variants to be generated as late as possible in the production process.

The further developed form of variant-flexible factories is the *customer specific factory*. It pursues the idea of mass customization, which will be discussed further in Sect. 4.10. In this situation, every order is different from the next with regards to technical specifications, quantity and due date. In the extreme case, the customer can configure the product themself via the internet, order it direct from the factory and follow its production over the internet as well. One of the conditions for this is that all business processes are mastered from the customer's order specification up to supplying the product to the customer.

If products are in the mature stage and thus subject to strong price pressure due to numerous competitors, the *low cost factory* is aimed at continually decreasing self-costs by strictly managing target costs, focusing on few products with large production quantities and consistently avoiding any kind of waste. This requires strict monitoring of the performance figures.

The described types of factories from the customer perspective will not appear in their pure form, since in real factories just about all of the strategic characteristics have to be taken into consideration with varying emphasis. In Fig. 2.13 the qualitative value of the competitive factors developed in Fig. 1.7 are depicted for the six factory types. It can be seen that the customer specific factory fulfills the most competitive factors, followed by the variant flexible factory.

The next dimension to be discussed in developing a morphology of factory types according to Fig. 2.10 is that of the *dominating organizational principle*. Here, factories can be differentiated as functional, segmented, networked or virtual.

The *functional factory* is organized into areas using the same technology through which a number of different products are routed e.g., mechanical processing, electronic manufacturing and assembly. This proves to be advantageous with regards to the utilization and flexibility of resources and bundling of know-how. Nevertheless, it is also associated with long through put times and large inventories resulting in stagnancy.

factory type ▷	high tech factory	responsive factory	breathing factory	variant-flexible factory	low cost factory	customer specific factory
feature ▷	technology	speed	volume range	variety	costs	customer request
competitive factors: costs	○	○	⊖	⊖	●	●
time	○	●	⊖	⊖	○	●
quality	●	○	○	○	○	●
innovativeness	●	○	⊖	⊖	○	⊖
learning speed	⊖	○	○	●	⊖	⊖
changeability	⊖	⊖	●	●	○	●

characteristic: ○ weak ⊖ middle ● strong

Fig. 2.13 Characterization of factory types from customer's perspective. © IFA G9586SW_B

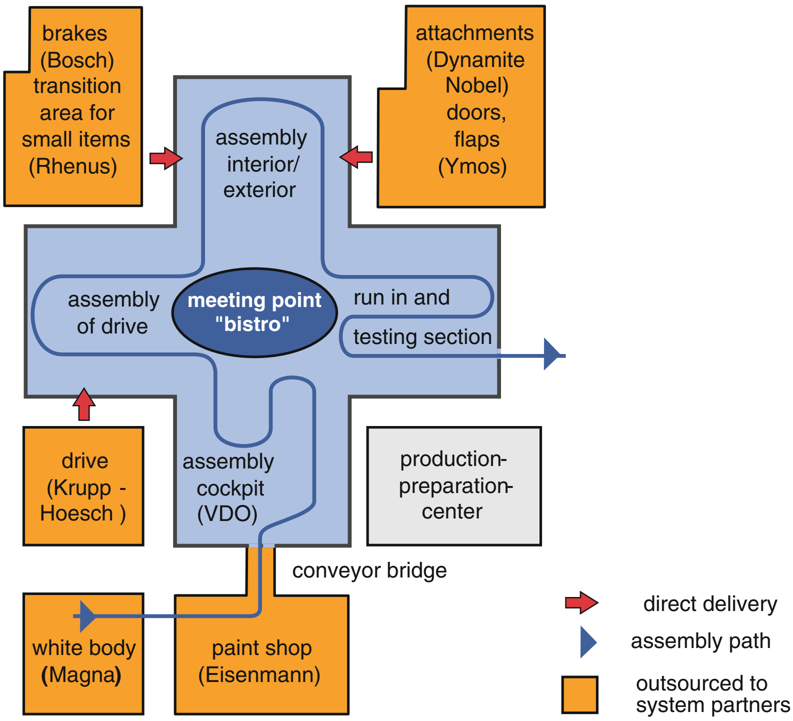

Fig. 2.14 BOT model example (based on MCC). © IFA G5341SW_Wd_B

If greater flexibility and more responsiveness are required, the *segmented factory* arises; comprised of powerful, small production units, clearly oriented on the product and market, it is also fully responsible for financial results. These units, depending on the quantity of the production and the number of variants, are then organized according to either the line principle, segment principle or workshop principle.

If the number of products and their variants is continually growing, reducing the complexity by drastically decreasing the in-house part manufacturing and suppliers is indispensable for preventing a collapse. Thus a *networked factory* emerges with several tiers of suppliers for subsystems, modules, components and parts. These are coordinated by intermediary logistics service providers.

In order to quickly seize opportunities for a complex product or system, a number of factories can temporarily join together for a project and bundle their processes and resources. Such cooperations are also plausible among competitors when it concerns utilizing very expensive equipment. When the enterprise that has the direct contact with the customer does not participate in the production itself, the term *virtual enterprise* is used. In extreme cases, these only look after marketing and processing orders.

In the fourth dimension of the factory morphology according to Fig. 2.10, the *ownership of property,* expresses itself in the production means. Starting with the objects that have the greatest risks many enterprises search for a release from the permanent tie to production plants through renting or leasing. There has thus been great interest in the abovementioned BOT models [Sche04, p. 441ff]. In these cases, either the plant manufacturer or an external service provider operates the production plant on the factory site or in the immediate near to it and delivers systems and components ready to be integrated in the final assembly. Figure 2.14 illustrates the BOT model based on the example of an automobile manufacturer which produces the compact Smart Car [Bar98].

In this case, 15 suppliers yield 80 % of the car's value-adding on the premises of the Micro Compact Car Company (MCC) located in Hambach, France. By skillfully bundling orders

views ▽	characteristic forms					
perception of the market	minimal price	variant flexible	volume flexible	reactive	high tech	customer specific
position in the supply chain	parts supplier	compo-nents supplier	module supplier	subsystem supplier	end product supplier	
orientation of the organization	functional	segment	networked	virtual		
ownership of production facilities	property	rent	leasing	cooperation	operator model	

Fig. 2.15 Morphology of factory types. © IFA G9585SW_B

across approximately 80 contractors 1000 positions in total are allotted as compared to 6000–8000 positions found in traditional automobile manufacturers. In this case, Magna operates the body shop and is paid for every automotive body it produces. The same applies to the paint shop operated by Eisenmann.

The plant operators thus act as their customer's problems solver, extending their competency as a plant manufacturer to include permanently controlling the production processes. This is not possible without their participation in developing both the end product and the entire factory; a long-term customer relationship is thus created. BOT models relieve the end product manufacturer from intensive capital investments and allow them to concentrate on the core processes of marketing and distribution, product development, final assembly and service. When there is a slump in the market, both partners are in the same boat and carry the corresponding risk. Nevertheless, the producer demands that the operator ensures the agreed upon quality, delivery reliability and price.

A further form of property ownership is cooperations in which two or more enterprises erect a production plant and use it for different products.

Based on the four dimensions described here, a morphology system for factory types results (see Fig. 2.15).

A factory—albeit still idealized—can then be described by combining one of each of the attribute forms from the four perspectives. A description such as this is particularly suitable as a basis for discussions about strategies when constructing or re-constructing a factory because it prevents the factory planning from becoming too focused on the subject of optimizing the layout and material flow.

2.8 Summary

The planning basis of a factory starts with the competitive factors found within the concerned industry. These include new entrants and substitutable products as well as the bargaining power of customers and suppliers. As part of the business planning a vision and strategy has to be developed, taking into account the perspectives of the customers as well as owners, the business processes and the ability to learn and grow.

The developed strategy describes the business sector, the market offer and the market segment. In doing so, sustainability in the economical, environmental and societal sense is vital. It is the strategy that first determines the design areas of the factory. These areas are concerned with the production facilities, organization and employees who interact within buildings on a site. The strategic orientation of the factory is still determined by the desired perception of the customer (function, price, high tech), the position of the products in the supply chain between the suppliers and customers (parts, modules, end product), the dominant principle of organization (functional, networked) and the owners of the means of production (ownership, rental, leasing, operating model). The resulting plant types can be characterized as high tech, responsive, flexible, breathing, variant, low-cost or customer-specific. In practice they tend to appear in mixed forms, since they usually serve several markets and customers with different products.

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