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Strategic Network Design

Focus Topic Paper

▶ Supply Chain Management
Logistics & Distribution



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Preface

More and more organizations recognize the significance of a robust, efficient and agile supply chain design for the success of their entire company. Nevertheless, I observe in day to day business that many companies still have to deal with historically grown supply chain complexity resulting from a legacy of local and regional structures and leading to supply chain inefficiencies.

In order to address this issue, companies established global management responsibility for the “supply chain” within their organizations. The strategic design and development of the supply chain network must, in my experience, be one of the key tasks for these organizations. Strategic network design has to ensure that the supply chain is ready to support the strategy of the business and sustain the competitive advantages of the company in the long term. Therefore, I encourage every company to place supply chain review and design on their strategic agenda.

Supply chain design projects need to be deliberate investments, embedded in and aligned with the overall business strategy. There are various approaches to supply chain design; I can therefore only recommend that you take your time to decide on the right approach for your individual situation. Besides shaping the future of your company, each supply chain design project is also a great learning exercise for understanding the business – use it to develop your company and your organization!

This focus paper provides an in-depth look at the tasks and activities related to strategic network design, and provides a valuable input on how to execute this kind of projects successfully. In particular this paper highlights which factors and practices are essential for overall project success. Furthermore, it gives a critical overview of optimization tools for network design that explains which business questions can be addressed but also discusses their potential limitations and requirements.

I believe that this will provide you with good guidance on your way towards your future supply chain!



Bernd Flickinger

Former President Logistics, Procurement and IT Division of BASF

Former CEO Global Customer Solutions DHL

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Executive Summary

As innovation leader for supply chain management and logistics, we continuously focus on the analysis of industry trends and the development of state-of-the-art methodologies to provide companies with pragmatic approaches and competitive strategies to dealing with current and future challenges. This focus topic paper provides insights into the current state of strategic network design and illustrates how network optimization can be used to create supply chains that efficiently support strategic business models.

There are three reasons to have strategic network design on the agenda:

- **Good network design means higher profitability:** effective network design optimizes investments in capital-intensive assets, lowers operational costs, and helps to reduce working capital in the supply chain while maintaining the targeted customer service.
- **Good network design means management of growth:** comprehensive network design determines where and when new facilities are needed to ensure that new markets can be accessed effectively and new products can be manufactured as needed.
- **Good network design means less business risks:** our business world is continuously changing. An optimal supply chain footprint reduces the supply chain's exposure to supply and demand risks by creating agility and flexibility at strategic level.

This paper provides you with:

- An overview of the current challenges and typical business drivers in the area of network design
- A strategic approach that translates an envisioned business strategy into your supply chain
- Insights into tools, methodologies, and design principles for strategic network design

You should read this paper...

- ... if you are seeking strategic ways to optimize capital expenditures and working capital in your supply chain while achieving a best-in-class customer service
- ... if you want to review your current supply chain design and assess its match with the strategic needs of your business
- ...if you are at the beginning of a network design project and want to know what factors and practices deliver the best results

1 Strategic network design ensures a competitive supply chain

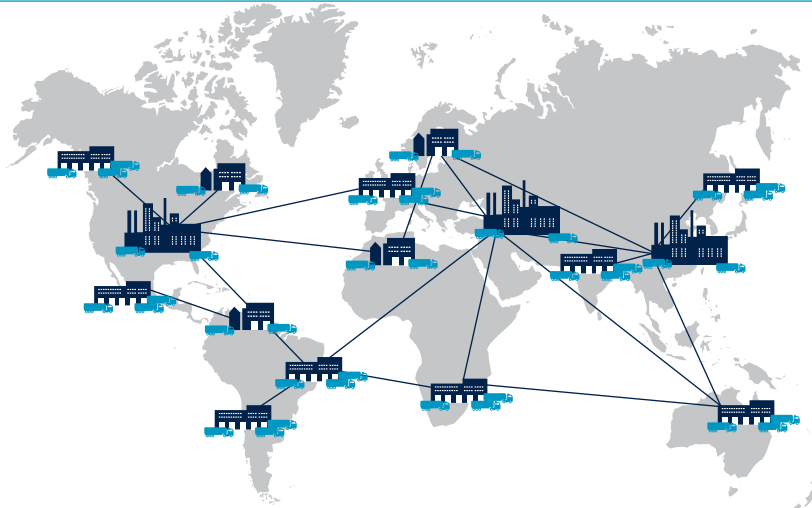
1.1 The strategic value of network design

Network design is the **strategic planning** process for evaluating alternative structures for a supply chain, and selecting the one that maximizes profitability and helps to improve performance at each link in the supply chain.

The design of robustly operating and highly efficient networks for global operations is widely perceived as one of the key challenges in supply chain management. Together with product research & development and strategic marketing, the right supply chain design is one of the essential tools for a company to achieve its **strategic business goals** and gain **sustainable competitive advantages**.

Network design plays a crucial role for companies in **all industries** striving to deliver outstanding supply chain performance. Companies pursuing global sourcing strategies, operating complex manufacturing networks, and serving their customers through a tiered distribution network are especially compelled to pro-actively address strategic network design considerations (Figure 1).

Figure 1:
Network design has to ensure the efficiency of global and often complex operations



The role of network design has become even more prominent in today's business environment, as companies have to cope with a variety of fundamental challenges in order to secure smooth material flows and satisfy sophisticated customer needs (see Figure 2). A holistic approach to network design, which is tightly aligned to the overall supply chain and corporate strategy, is required to ensure success in today's demanding markets.

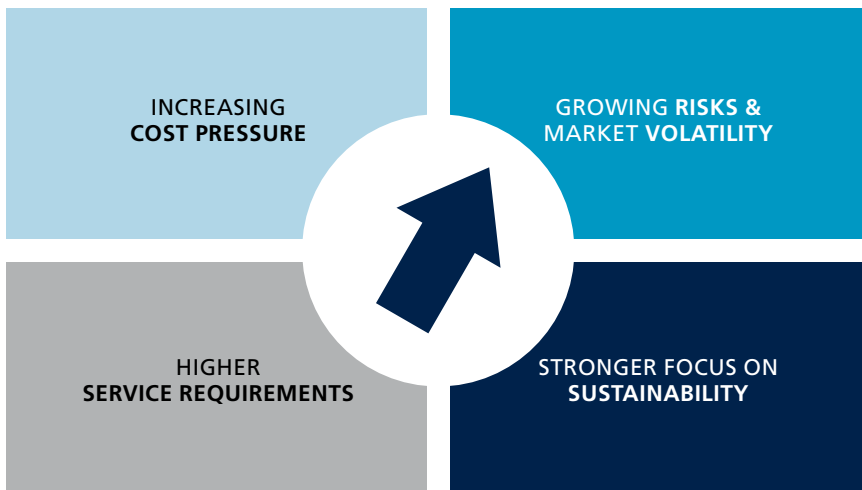


Figure 2:
Key characteristics
of today's com-
petitive markets

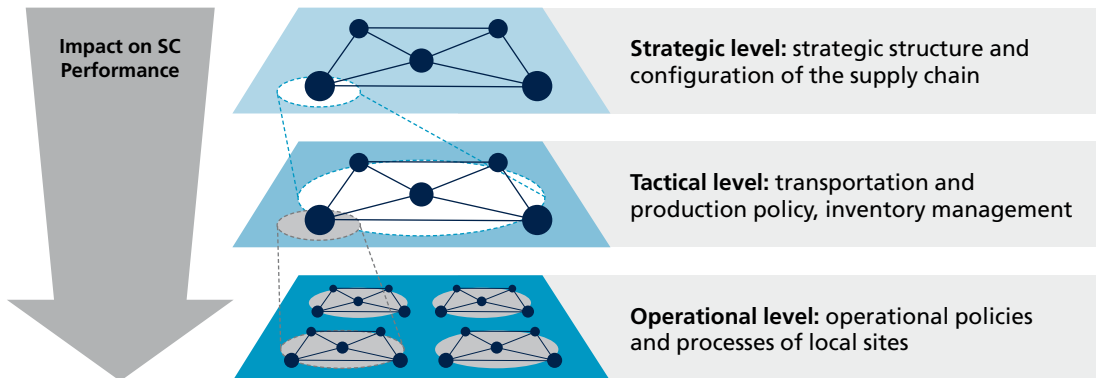
If delivered successfully, strategic network design improves a company's supply chain performance in a variety of areas:

- Higher return on assets as network design optimizes capital-intensive investments that are typically of a highly irreversible nature.
- Lower supply chain cost as network design sets the conditions for ensuring operational efficiency of virtually all supply chain-related functions and processes.
- Reducing the supply chain's exposure to supply and demand risks.
- Creating strategic preconditions for responding to changes in the business environment and enabling future growth.
- Higher customer service and lower time-to-market for new products through lower lead times throughout the supply chain.

1.2 Strategic network design affects the whole supply chain

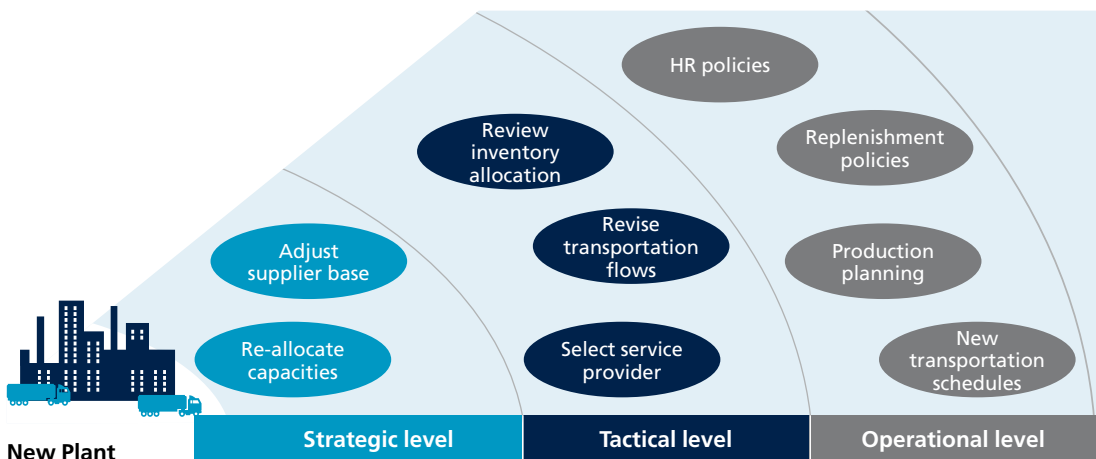
Strategic decisions made at network level affect all levels of supply chain management and provide the framework for successful tactical and operational supply chain processes (Figure 3).

Figure 3: Network design decisions impact on all levels of supply chain management



The far-reaching implications of strategic network design can be illustrated by taking the practical example of establishing a new production facility (see Figure 4). A variety of decisions have to be made to integrate efficiently the new facility into the existing supply chain and secure the required service levels. Supplier base and production capacities are typically subject to strategic considerations, while at a tactical level the respective transportation and material flows have to be aligned. Operational decisions are predominantly linked to local site processes, for instance regarding replenishment policies and transportation schedules.

Figure 4: Opening up a new production plant triggers various decisions at all decision levels



1.3 Business drivers and typical questions for strategic network design

There are many drivers that can prompt companies to initialize network design projects. Nevertheless, considering the constantly changing economic environment and the significant contribution of an optimally designed supply chain to overall business success, companies are well advised to **continuously evaluate** the performance of their networks and place supply chain review and design on their strategic agenda.

Depending on the actual business requirements, companies might consider either **re-designing their supply chain** or **designing a new chain** so as to align their networks with changing business conditions or meet new strategic objectives (Figure 5).

Supply chain re-design is typically driven by changing market and business conditions, frequently in conjunction with elevated cost pressure and service requirements that for example require expanding or restructuring operations. If a company grows through external acquisitions, network re-design addresses the integration of acquired operations in order to fully exploit all benefits and synergies at supply chain level.

The need for designing a new network emerges when a company enters new geographical markets or grows into new product segments. Also, companies might want to analyze a so called “greenfield” approach to evaluate how far their existing supply chain design deviates from an optimal footprint.

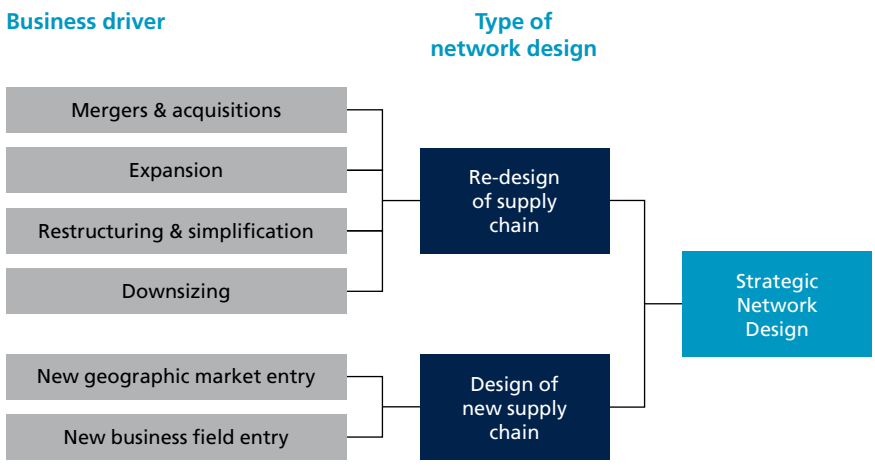
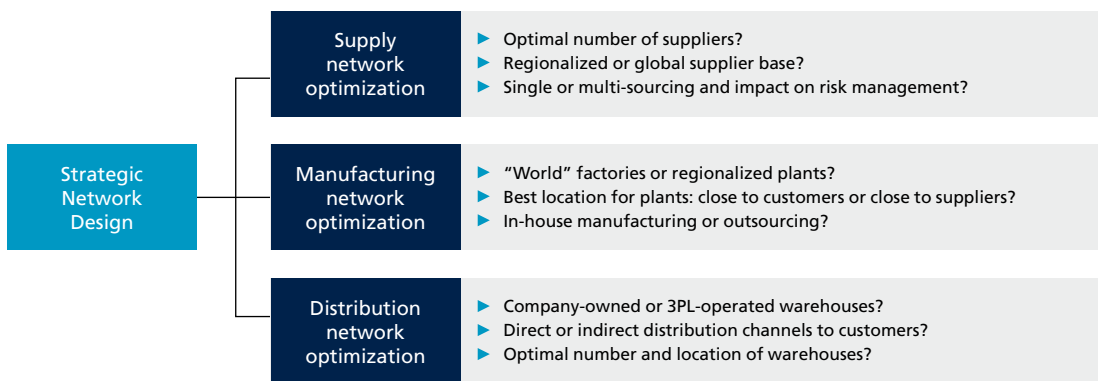


Figure 5: Different drivers for strategic network design

If the supply chain network in place does not optimally support the targeted business model, network (re)-design should be considered as a solution for achieving the strategic objectives by answering **key business questions** with regard to different supply chain segments (**supply, manufacturing and distribution network**). As shown in Figure 6, a well-structured network design approach provides optimal answers regarding supplier base, manufacturing footprint and distribution systems, and establishes the basis for far-reaching network design decisions.

Figure 6:
Typical business questions answered through strategic network design



2 Aligning network design with strategy

2.1 The business strategy has to be the ultimate starting point for network design

Network design translates an envisioned business **strategy** into the supply chain. Therefore, you have to ensure that your decisions regarding network design are driven by your company's strategic direction.

As shown in Figure 7, there are four **key strategy dimensions** which primarily characterize such considerations. Strategic network design makes a significant contribution to achieving the desired performance in each dimension. Network design affects the cost dimension through optimizing both capital and operational expenditures, and the service dimension, for example through providing appropriate customer service levels. Internal throughput times as well as lead times to customers affect performance with regard to time, while agility captures the capability of a supply chain to respond to changing requirements.

As high performance in each dimension would be typically neither economically justified nor even feasible, it is crucial to align network design with the optimal strategy regarding products and markets, and to carefully investigate the potential **trade-offs** between the different performance dimensions. When designing a supply chain, it is therefore critical to understand the **different requirements** of the various product or customers segments. For example, **innovative**, high margin products might require a different strategic positioning than less risky but low margin **commodity** products (see Figure 8).

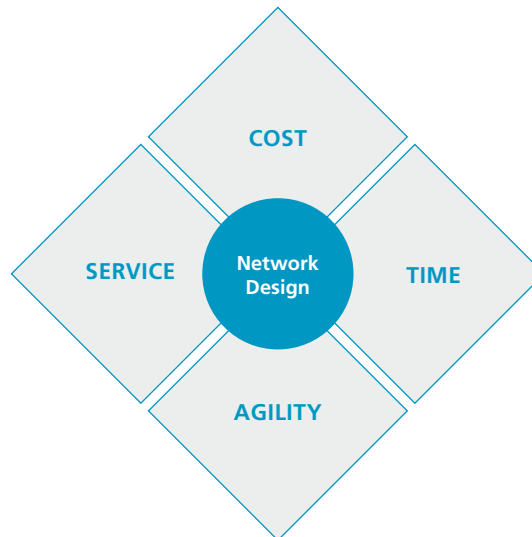


Figure 7: Key strategy dimensions that affect network design

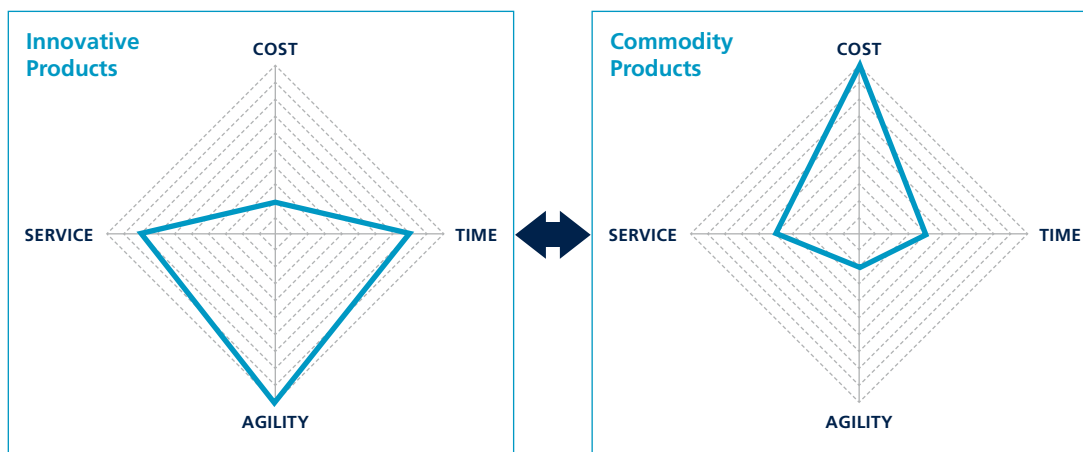
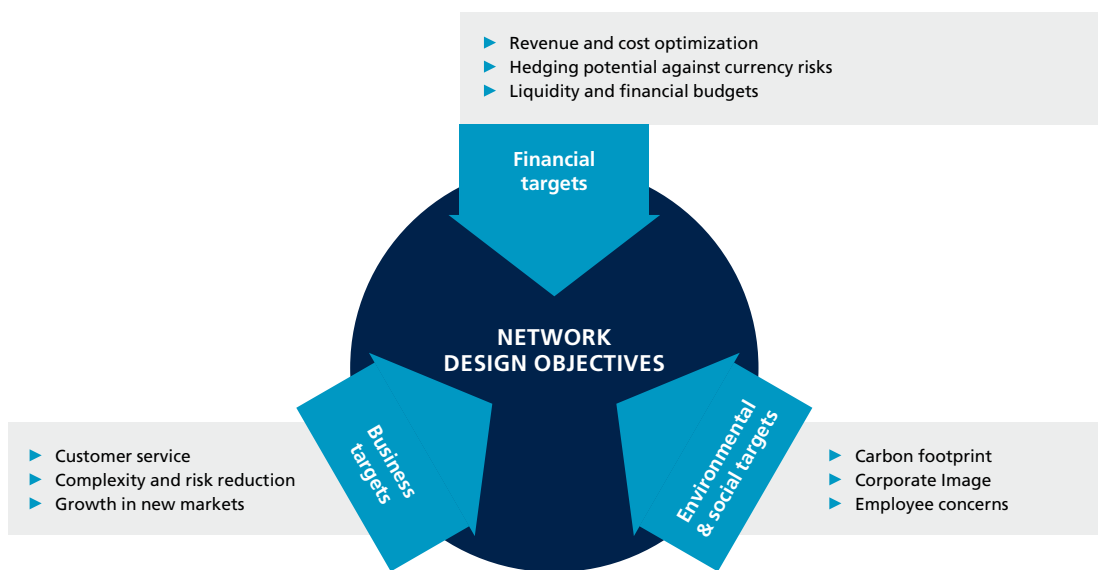


Figure 8: Example for different strategic requirements that need to be considered in network design

2.2 Objectives and reference models for strategic network design

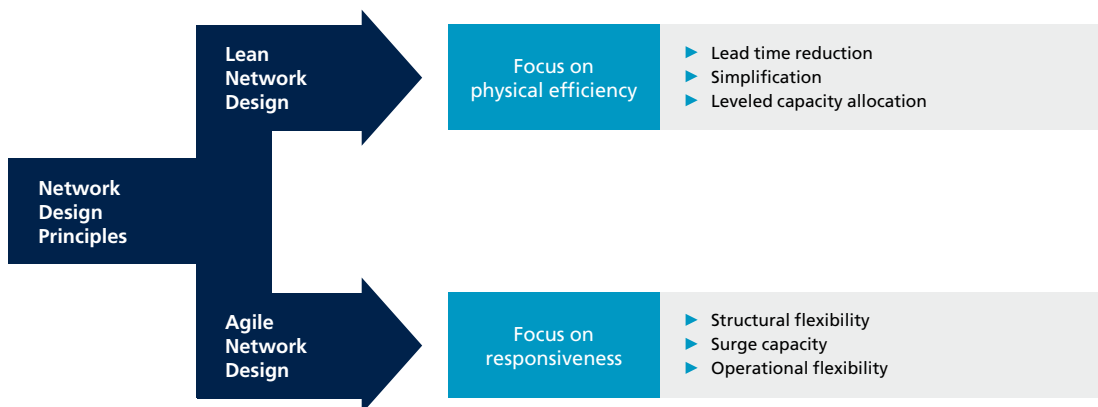
It is crucial to derive the concrete objectives for network design based on the envisioned business strategy. While you might consider different objectives, you should focus on the objectives that support the intended business strategy. Objectives for network design can be either **financial targets**, **business targets**, or **social & environmental targets** (see Figure 9 for examples). While some of these objectives complement each other, other targets might be conflicting. Therefore, you should carefully assess which goals will help to implement your target strategy, and set feasible targets accordingly.

Figure 9:
Objectives pursued through strategic network design



When defining the strategic direction and objectives for a supply chain, a key question for companies is: which principles should guide their strategic network design? Industry benchmarks as well as state-of-the-art research studies point out that companies are well advised to follow two main design models: **Lean network design** and **agile network design** (Figure 10). These two reference models can help to guide you in selecting objectives and identifying the right scope for supply chain design.

Figure 10:
Reference models for strategic network design



Lean network design focuses in particular on the following aspects:

- **Lead-time reduction** is characterized by optimizing internal throughput times and lead times to customers.
- **Simplification** reduces network complexity, for instance by concentrating products or processing steps at certain facilities and outsourcing the processing steps that add less value.
- **Leveled capacity allocation** eliminates capacity bottlenecks and helps to avoid over-investment in assets and low utilization rates.

Agile network design focuses on the ability to respond rapidly and cost-efficiently to changes in the business environment. The following factors characterize an agile network design:

- **Structural flexibility**, e.g. through flexible plants and flexible workforce models, allows you to respond to demand fluctuations or supply chain disruptions. A flexible manufacturing footprint also forms an efficient hedge against currency and cost risks.
- **Surge capacity** at the plant and supplier level ensures that the supply chain can provide high customer service when demand increases.
- **Operational flexibility**, such as multi-sourcing strategies and flexible transshipment modes, makes supply chain processes capable of dealing with short-term changes in operational requirements.

It should be emphasized that the two design approaches are not mutually exclusive, but rather **complement each other** in several cases. Consider again the case of innovative versus commodity products (Figure 11). While innovative products typically face higher market uncertainty and thus require a substantial degree of supply chain agility, lean principles are the predominant design approach for more stable commodity products. However, lean network design also supports the efficiency of delivering innovative products to the market, e.g. through lead time reduction approaches.

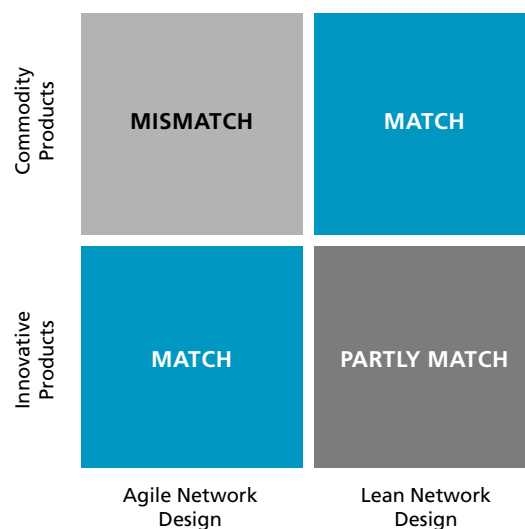


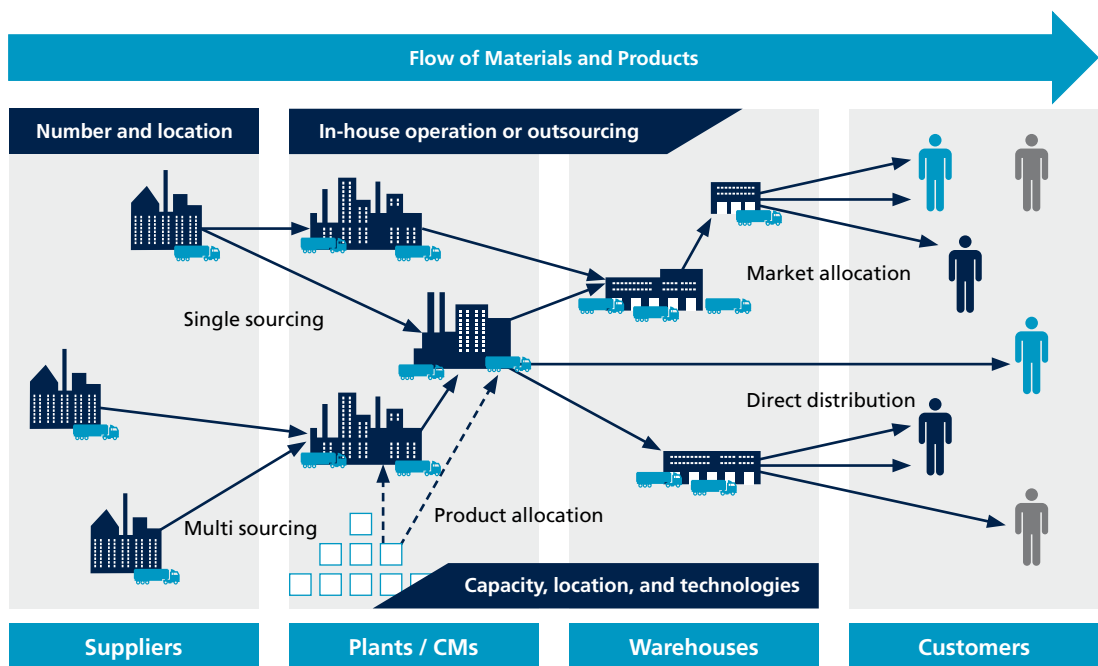
Figure 11:
An example of how network design approaches should be mapped to product segments

To ensure that network design goes in the right direction, matching potential design alternatives with identified strategic requirements should be an integral part of the whole network design process.

2.3 Key decisions for strategic network design

In order to ensure that the whole supply chain follows strategy and objectives and to identify the right scope for a network design project, it is essential to take an **integrated** and **comprehensive view** on the whole supply chain, including key suppliers, the various manufacturing facilities, all warehouses, transportation channels, and the end customers. This “cradle to grave” approach in terms of geographical and functional scope can help companies to achieve and maintain outstanding performance in their supply chain in the long run.

Figure 12:
Key decisions for strategic network design



As shown in Figure 12, network design can help to define the optimal number and location of facilities (manufacturing plants, warehouses, and distribution centers), the allocation of capacity and technology requirements to facilities, the assignment of products to plants, and the flow of goods throughout the supply chain. Furthermore, network design should determine whether services and processes should be conducted internally or externally. For example, network design projects can be used to decide whether products should be manufactured in-house or by contract manufacturers, taking into account all of the implications for the supply chain.

You should be aware of the fact that to reach optimal decisions, you typically need to **balance different objectives**. For instance, the trade-offs between conflicting cost objectives affect the optimal degree of centralization in a company’s distribution network (Figure 13). Companies aiming to decide on the optimal number of distribution centers have to ensure that all relevant cost dimensions are adequately incorporated, in order to minimize total supply chain costs while maintaining or improving delivery service levels.

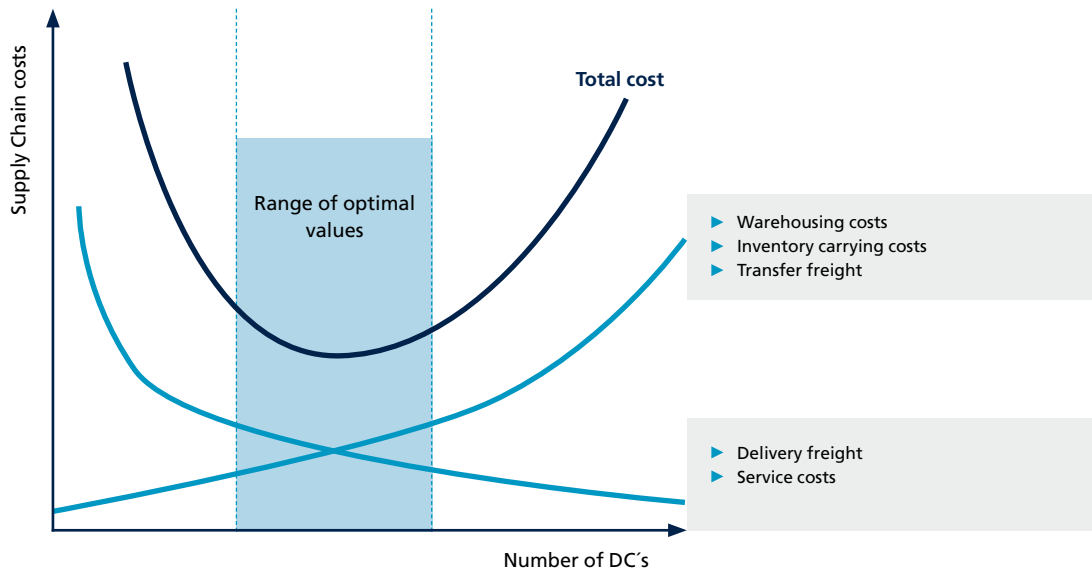


Figure 13:
 Example of cost trade-offs when designing a distribution network

The complexity of network design problems becomes obvious, even on the basis of this rather simple example. However, there are typically far more objectives, constraints and dimensions that have to be considered at different planning levels. That is why network design should in most cases be supported by **business analytics** and **optimization tools** capable of addressing all relevant factors and trade-offs.

3 How to approach strategic network design

3.1 Strategic network design wisdoms

The ultimate goal of a strategic network design project is to gain competitive advantages and secure long-term success by providing the right structure for the supply chain. To accomplish this goal successfully, this section shows several design wisdoms consisting of **success factors** for network design and **best practices** for the design process.

Figure 14:
Key success factors for strategic network design



As shown in Figure 14, there are **five key success factors** in particular which ensure that a network design project yields a practically feasible plan for the supply chain. As argued in the previous chapter, the business strategy needs to be the ultimate starting point for supply chain design. Consequently, supply chain design must be driven by strategic views and closely aligned with the strategic targets of a company. When designing a network, it is crucial to ensure that the envisioned design is capable of meeting the future requirements, given the typically high investment volumes and the limited reversibility of decisions. An integrated and holistic design approach should consider the supply chain as a whole, assessing both strategic and operational aspects. During the whole network design process, the possibilities for implementing the designed network must be comprehensively studied. In the end, a practicable design needs to mirror the organization in place. As it is not uncommon that network design projects cause significant changes to a supply chain, organizational alignment needs to be supported by adequate change management activities.

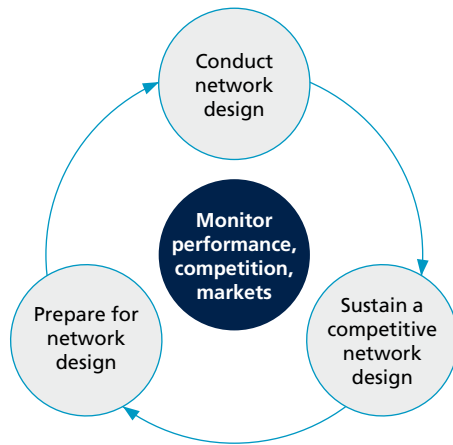


Figure 15:
The network design cycle

Because of constant changes in the business environment, companies should not consider network design as a one-time exercise. Instead, the whole network design process should be regarded as a **continuous improvement cycle** consisting of the right preparation of network design projects, the execution of these projects in response to business needs, and sustaining a competitive network for the supply chain (see Figure 15). Once the supply chain design has become outdated, the cycle should start again. Experience shows that simply following a couple of best practices helps significantly to increase the success of network design projects, and thus to develop a competitive supply chain footprint.

PREPARE FOR NETWORK DESIGN

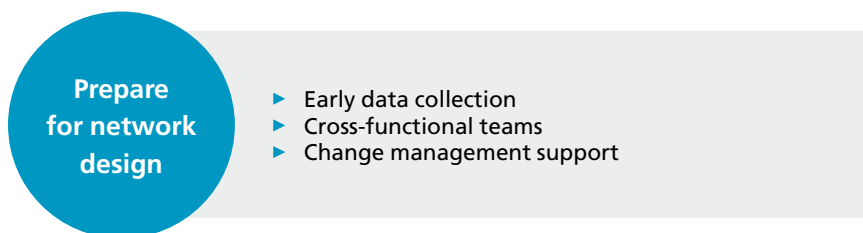
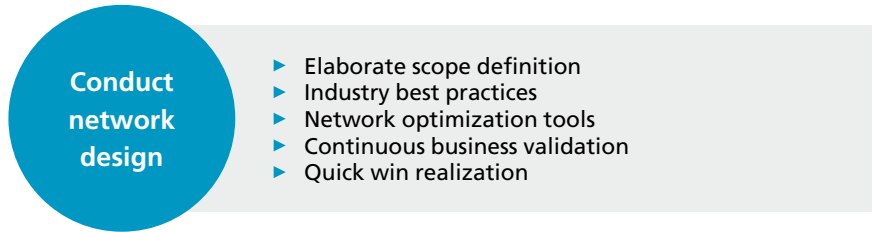


Figure 16:
Best practices for preparing network design projects

Data is the key for a comprehensive design of the supply chain. The effort required for data collection should not be underestimated (especially if model-based approaches are considered), but at the same time the collected data offers many additional opportunities for business improvements. Therefore, sufficient time and resources should be dedicated to data collection. Cross-functional project teams consisting of all supply chain disciplines and neighboring departments, such as customer service or R&D, make sure that the analysis covers all relevant angles. In order to ensure both acceptance and business practicability of the envisioned network, a structured change management approach encompassing change planning, stakeholder management, organizational alignment, and appropriate communication is highly recommended from the beginning.

Figure 17:
Best practices for conducting network design projects

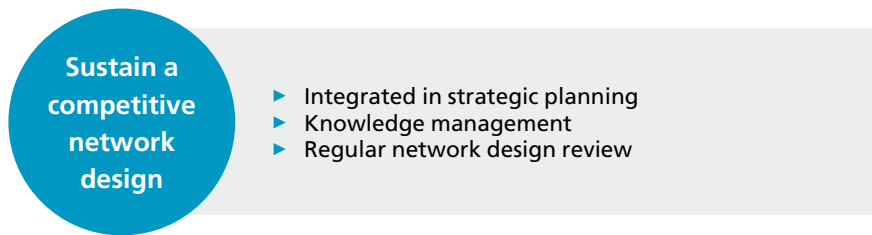
CONDUCT NETWORK DESIGN



There are various approaches to supply chain design. To define the appropriate project approach, you should start by elaborating the right scope very thoroughly. Industry best practices should guide the development of suitable business scenarios (e.g. centralization versus decentralization strategies), while network optimization tools can help to visualize, evaluate and optimize the envisioned business scenarios. A continuous validation of all project results (e.g. business scenarios, data, and model results) by cross-functional teams and relevant stakeholders ensures feasibility and organizational acceptance of the designed network. You should be aware that systematically collected and analyzed data provides a lot of insight into your own supply chain. Based on this data, immediate improvement opportunities, such as inefficient shipment sizes or inappropriate use of express shipments, can be identified and even realized before a new network structure is in place.

Figure 18:
Best practices for sustaining a competitive network design

SUSTAIN A COMPETITIVE NETWORK DESIGN



It is highly recommended to establish supply chain review and design as a regular part of the strategic planning process. Considering the constantly high pressure on supply chain performance, clear organizational responsibilities can help to establish a regular review of the supply chain network in place, as advocated by the network design cycle. To continuously improve capabilities and know-how regarding concepts, modeling, and potential tool-based approaches for network design, the results and data of past projects should be an integral element of a company's knowledge management. To this end, a company might also consider to establish an own organizational unit responsible for network design if it faces network design questions such as product or capacity (re-)allocation frequently.

3.2 The strategic network design process

Generally, the strategic network design process should run through a **structured sequence of planning steps** (see Figure 19).

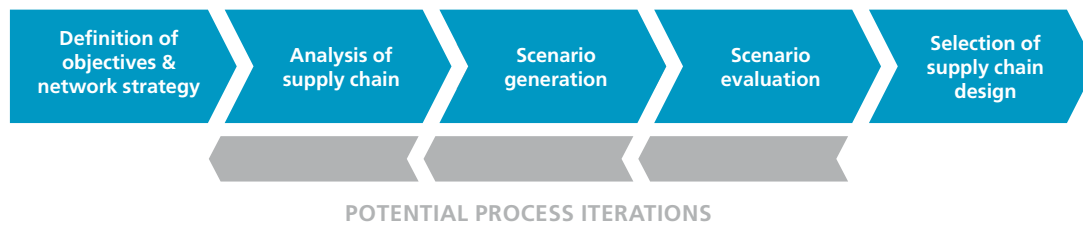


Figure 19: Strategic network design should rely on a structured process

The main phases of the network design process can be summarized as follows and should be accompanied by the best practices described above:

- **Definition of objectives and network strategy:** Identifying all relevant targets in alignment with the overall supply chain strategy, ranking them according to their relevance, and investigating appropriate trade-offs are extremely important prerequisites for a successful network design project.
- **Analysis of the supply chain:** An in-depth and future-focused analysis of the as-is supply chain using information and data from IT systems as well as from key stakeholders helps to identify current strengths and weaknesses and to refine objectives.
- **Scenario generation:** Alternative supply chain scenarios are developed from a business perspective. To elaborate the business scenarios, optimization tools can be used in this phase, for example to decide on optimal facility locations or capacity levels.
- **Scenario evaluation:** The developed scenarios undergo a validation and prioritization process. Both quantitative and qualitative factors have to be taken into account when ranking the identified scenarios according to their benefits and business feasibility.
- **Selection of supply chain design:** A detailed business case and implementation plan is essential for the final selection of a certain scenario. Typically, this is only done for a few scenarios which have been evaluated as the best ones.

During the entire process, suggestions for the investigation of additional scenarios and objectives or modified alternatives may arise. As a consequence, the middle phases of the process may go through several iterations. Appropriate analytical tools for optimization and simulation can significantly speed up and improve the outcome of the whole network design process.

3.3 Which tools can support strategic network design?

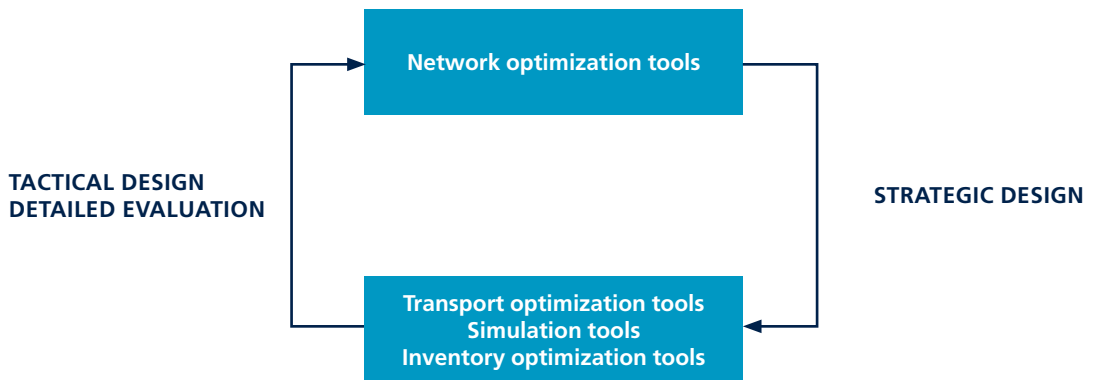
The **benefits of optimization tools** unfold especially in the middle stages of the network design process (see Figure 20). Network design tools support in particular the analysis of the current supply chain by providing in-depth statistics and visualization functions, and simplify the design and evaluation of alternative supply chain scenarios.

Figure 20: Use of optimization tools during a network design project



The question is often the following: which tool should be used to adequately support a network design project? The range of instruments for modeling a network varies substantially in complexity and detail. While simple modeling problems can be solved using Excel and Access based applications, more complex problems might require optimization and simulation approaches. As shown in Figure 21, **network optimization tools** are especially suitable for supporting strategic decisions such as the location and capacity of facilities in the network, while **tactical optimization tools** and **simulation engines** refine and complement strategic design at the tactical level.

Figure 21: Tools that support strategic network design



Network optimization tools use state-of-the-art mathematical algorithms to determine the optimal location and capacities of facilities and suppliers, and the optimal routing of logistic flows throughout the supply chain network (see Figure 22). They find optimal decisions through maximizing profit or optimizing cost objectives, taking into consideration revenues and all relevant cost components (transportation, warehousing, manufacturing, sourcing) with respect to network constraints such as available capacities or lead-time requirements. Consequently, these should be considered if you want to find the best solutions among **multiple alternatives** while simultaneously considering **multiple constraints** and potentially **conflicting objectives**. Sensitivity analysis of the models allows you to study the impact of **changing business conditions** (e.g. demand growth or fuel price changes) on the network structure and expected costs.

However, you should be aware of the fact that these tools require a certain level of aggregation (e.g. the aggregation of demand on a yearly basis) to work properly.

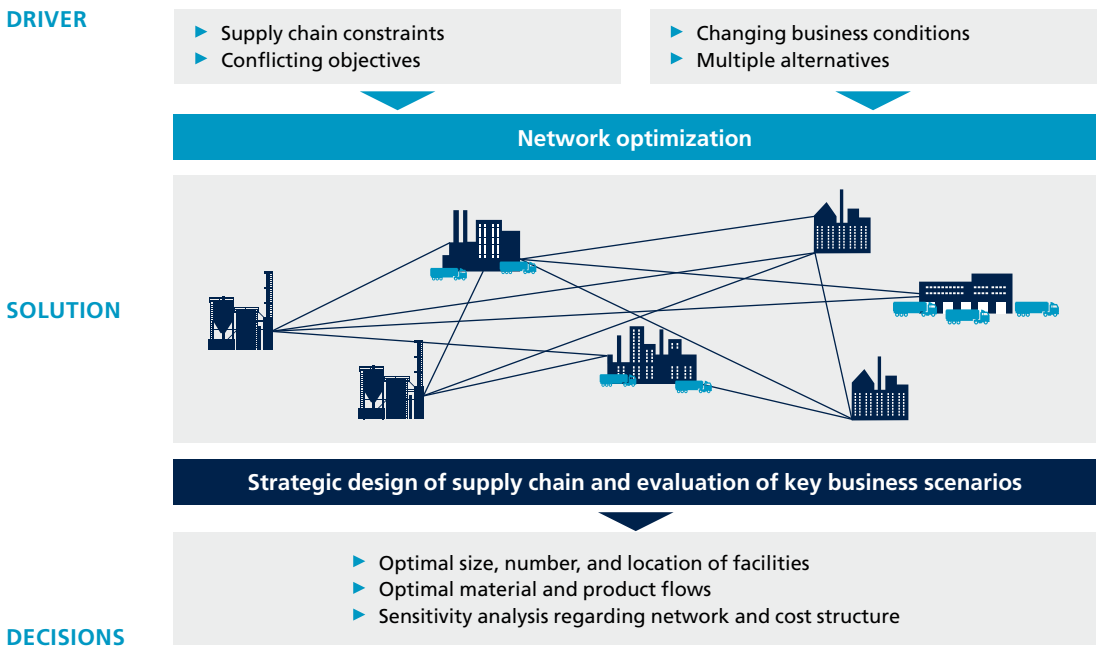
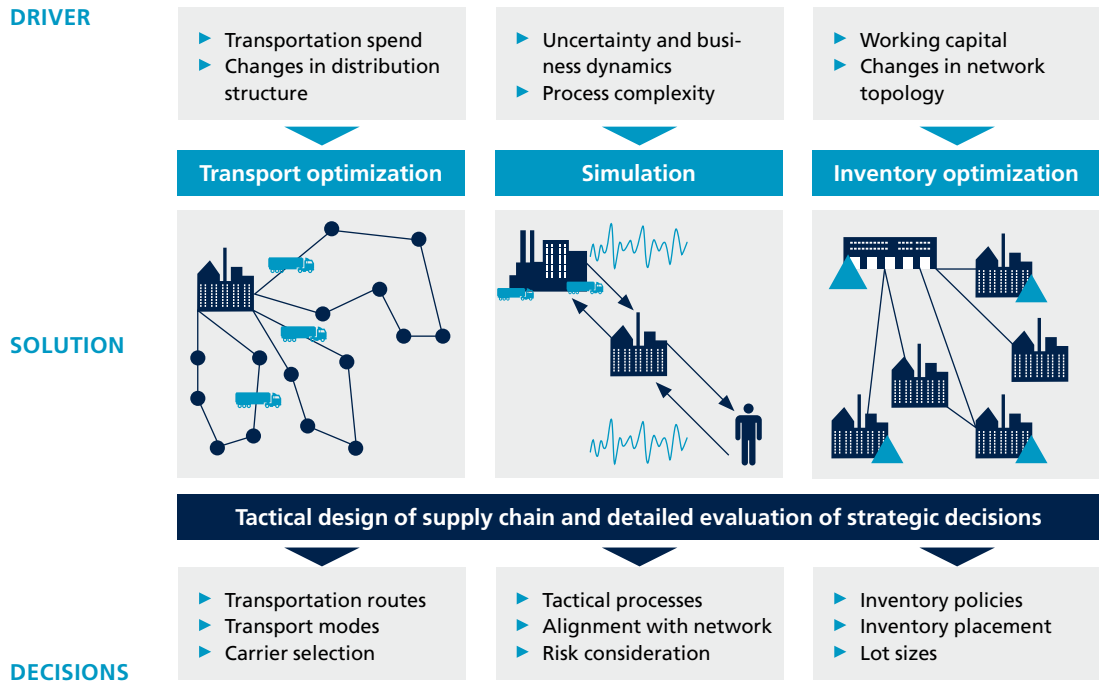


Figure 22: Application areas for strategic network optimization tools

Once the structure of the supply chain has been defined, you might consider tactical optimization tools as well as simulation approaches (see Figure 23). Significant **changes in the topology** of a supply chain can force companies to review transportation policies as well as inventory management, and align them with a newly designed network structure. For example, if a distribution system is centralized, optimizing inventory placement and consolidating material flows can help to unlock the full savings potential, especially if **transportation spend** and **working capital** reduction are important drivers. In the end, while all optimization tools require simplifications to keep models tractable, simulation approaches can analyze supply chains at virtually unlimited level of detail. Although simulation does not optimize network parameters, it is very helpful for understanding the real life behavior of a supply chain by taking into consideration the full **process complexity** and system **dynamics** and **uncertainties**.

Figure 23:
Application areas for simulation and tactical optimization tools



Tools for network design can provide substantial decision support in network design projects. However, companies should also be aware of their prerequisites and potential restrictions. The following **guidelines** in particular ensure that network design tools lead to success:

- Before using any tool, you need to define the relevant supply chain scenarios that match strategy and meet business requirements. Once these scenarios and thus the scope for network design have been clearly outlined (e.g. consideration of network centralization as a business scenario), tools can help to develop and evaluate the envisioned scenarios.
- Tools have limitations regarding the complexity of what can be modeled (e.g. aggregated product groups, customer groups, considered constraints). Model results will only meet business reality if the key business aspects are adequately covered. Therefore, you should take time to consider how relevant business aspects can be translated into a model, and validate this thoroughly.
- Actual decisions need to be taken from a business point of view. You should therefore carefully evaluate all model results, and assess the feasibility of the model in reality. Besides quantitative factors analyzed in a model, qualitative aspects such as organizational compatibility also need to be taken into account in order to ensure a successful supply chain design.

4 Strategic network design in practice – a case study

4.1 Challenge

The following case illustrates the results of a network design project for a leading chemical company with multi-billion annual revenue figures. The European supply chain network before re-design is shown in Figure 24.

In the course of a comprehensive network optimization project, the following main challenges and business requirements had to be met:

- The company operated a dispersed and less harmonized distribution network in Europe with multiple regional facilities, resulting in high inventory levels and substantial costs for transportation and warehousing.
- Capacity bottlenecks represented a serious challenge at one major manufacturing site, while other plants had significant idle capacity.
- The redesigned network had to support the company's expansion plans in the Middle Eastern markets.
- Due to rigid corporate guidelines for investment projects, the overall project had to ensure an early payback period and significant savings in the early phase of implementation.

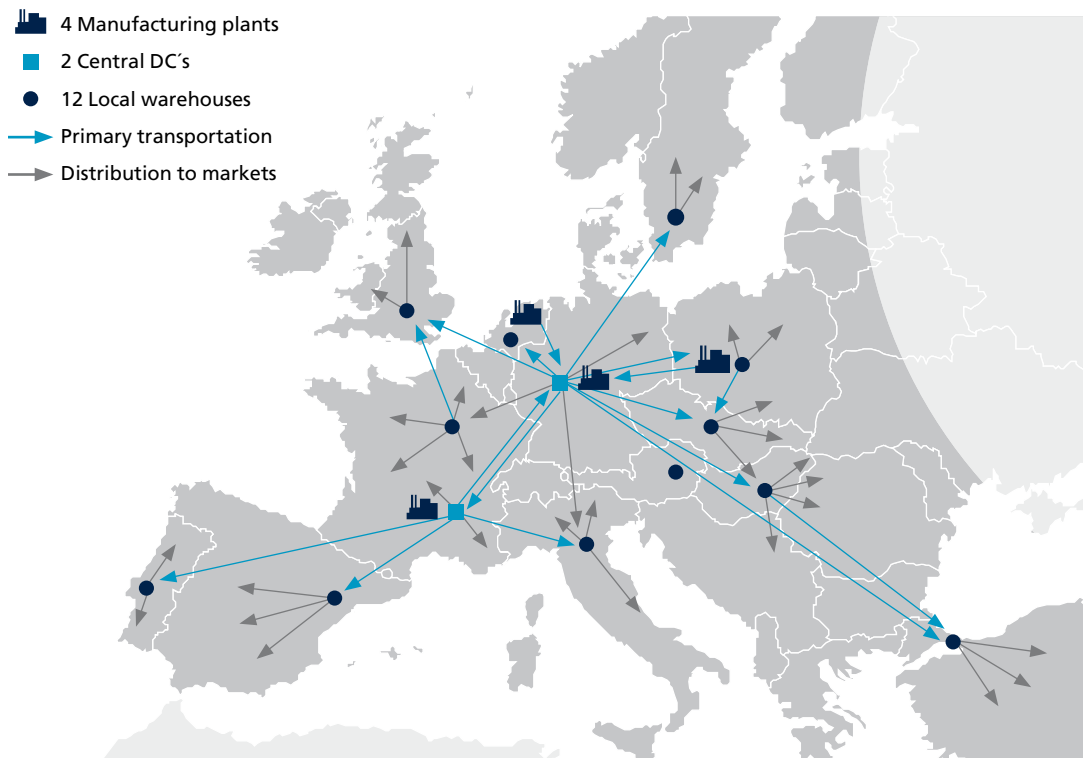


Figure 24:
European supply chain before network design optimization

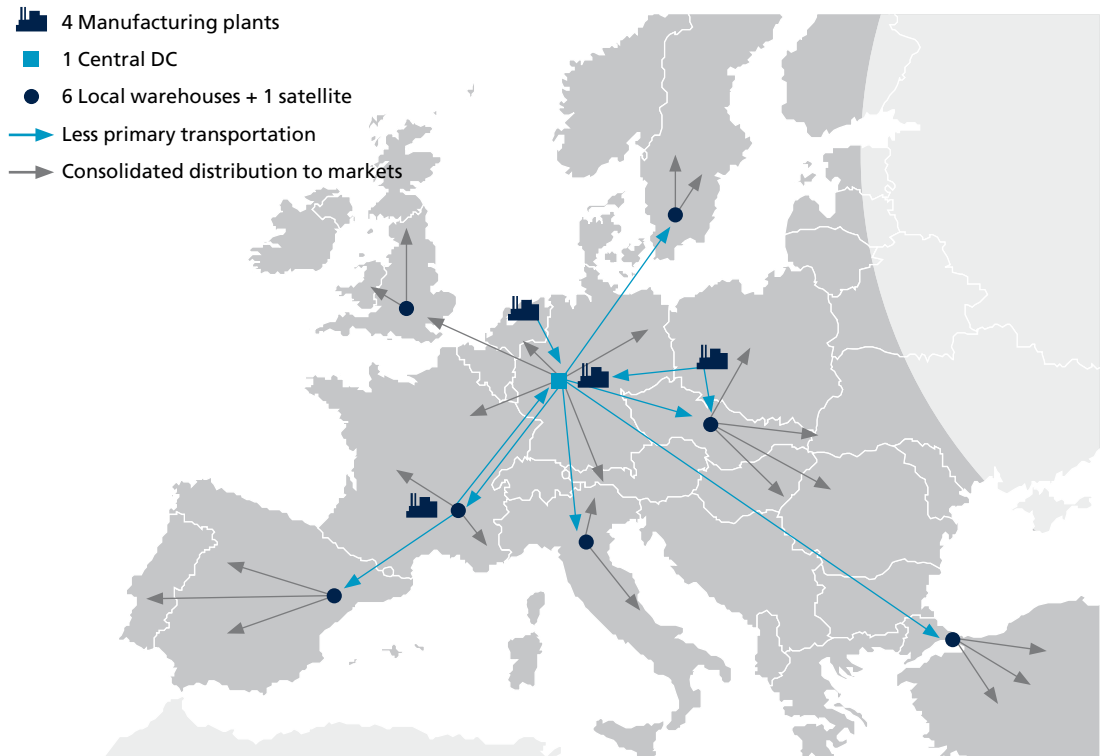
4.2 Results

In-depth analysis of supply chain data and processes revealed initial improvement potential and laid the ground for the modeling of future scenarios. Following the company’s envisioned strategy, a particular focus was placed on reducing complexity. During the project different business scenarios were developed and investigated which varied in the degree of centralization and thus network complexity.

To re-design and truly optimize the network, the project team decided to use a network optimization tool capable of optimizing warehouse locations, re-allocating product to plants, and defining cost-optimized material flows. The volume and cost information from ERP systems and logistic service providers formed the data basis for the model. The resulting alternatives were evaluated by the different business functions (logistics, manufacturing, and customer service) with a strong emphasis on availability of logistics service providers, customer lead times, and differences in demand growth and product portfolios across countries.

A detailed business case and implementation plan led to the new footprint illustrated in Figure 25. To ensure a smooth implementation of the intended changes, intensive change management and communication with stakeholders was an integral part of the project from the beginning.

Figure 25:
Optimized European supply chain network



The minimum network cost resulted in a scenario with 6 local warehouses with 1 satellite in Scandinavia, delivered from one central hub in Central Europe. The reallocation of products to manufacturing sites led to less primary transportation, more leveled capacity consumption, and eliminated former capacity bottlenecks.

Overall, supply chain costs were reduced by 11%, accompanied by an 18% reduction in inventories. Table 1 summarizes the key facts of the significant reduction of complexity in the supply chain. In addition, identified quick wins such as improved shipment sizes and renegotiations of transportation contracts led to early realization of savings.

| | Before re-design | After re-design |
|------------------------------|------------------|--------------------|
| Average capacity utilization | 78% | 87% |
| Distribution hubs | 2 | 1 |
| Local warehouses | 12 | 6+1 (satellite DC) |
| Transport service providers | 21 | 5 |
| SC cost | 100% | 89% (of baseline) |
| Inventory | 100% | 82% (of baseline) |

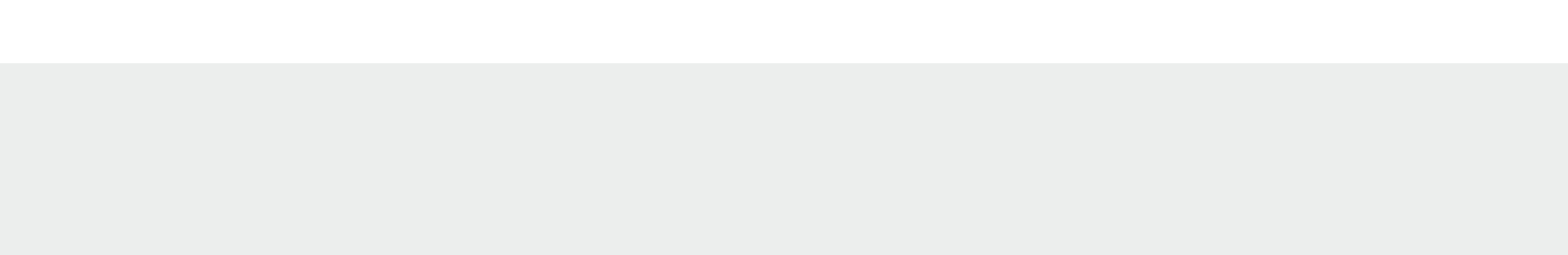
Figure 26:
Key complexity reduction factors and cost savings after European supply chain re-design

During the network design project, the benefits of regularly reviewing the supply chain were intensively discussed. As an outcome, the company decided to integrate a tool-based network evaluation in their strategic planning processes.

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