Design and optimization of logistics networks for global dislocated industrial companies

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Abstract: The economic globalization should not be understand only as world-wide trading scheme, but rather as decentralized value chains in industrial production. From this it follows that complex global networks with a large number of partners, e.g. suppliers, manufacturers, subcontractor, resellers and dealers, are arising. To design and organize such globally distributed networks we need an efficient information management and especially high-performanced decision support systems (DSS) for logistics planning.

The basic structure of a DSS is presented, based on the tool 4flow vista. It enables the logistics planner to manage the growing complexity of (logistic) networks. These can be modeled to calculate the processes, visualized to present the attained results and evaluated. The tool also allows the planner to constantly check, replan and to document the logistic processes. These tasks become more and more important, because closer partnerships in globalized supply chains lead to an increasing integration of all suppliers, subcontractors, resellers and dealers. Moreover, prospective suppliers and new plants have to be added and services might be outsourced to subcontractors. Taking these preconditions into consideration, the optimization of structures and processes is an even greater challenge for logistics planning. Due to shorter network replanning cycles, planning efforts increase disproportionally.

1 Introduction

Structures and processes of logistics networks within global operating industrial companies (e.g. engineering, automotive, aerospace) are influenced by changing structural conditions, increasing competition as well as continuously growing customer requirements. Within the near future logistics planners have to face the following changes:

- During the past years the globalization of *supplier*, *manufacturing* and *distribution networks* has increased rapidly. Today future markets with significant growth are mainly seen in regions far away from the traditional production sites in Central Europe and North America. Dynamic developments can be more and more recognized in Asia and Eastern Europe e.g. for the automotive industry. But the growing *network complexity* is not only a result of globally distributed networks but also of a large number of partners within: suppliers, manufacturers, subcontractors, distributors, resellers and dealers. Trucks, trains, vessels or planes with varying capacities and tariffs ship parts, components and finished products between those locations. Pressure is also created by steadily decreasing timeframes e.g. for manufacturing or transportation.

- It is obvious that the *real net output ratio* of single network partners is changing. Closer partnerships in production networks lead to an increasing integration of suppliers and subcontractors. As a result modularization in process chains increases. 1st tier suppliers become module or component suppliers, delivering their products *just-in-sequence* (JIS) to the production line of the next upstream level manufacturer. This calls for new ways regarding to 'on-time material supply', as well as stock, warehouse and transportation planning.

- Established networks with global supplier and customer relations are questioned by an increased *product diversity*, production of smaller batches and the trend towards shorter *product life cycles*, especially concerning *high tech-market segments*. Production and delivery of new products and goods have to be integrated into *existing networks* to guarantee cost-efficient structures. Moreover, prospective suppliers and new plants have to be added and services might be *outsourced* to *subcontractors*. Taking these preconditions into account, the optimization of structures and processes is an even greater challenge for logistics planning. Due to shorter (network) replanning cycles, planning efforts increase disproportionally in globalized markets.

- A huge variety of parts and a wide diversification of part properties and features are typical for networks of discrete industry companies, that often count up to several 100,000 article numbers. The planner has to take into account special handling and storage requirements, specific loading and shipping equipment and its flow of empties as well as varying stock ranges for low and fast moving products under the constraint of high availability. In addition, customer stocks and pooled stocks have to be considered e.g. in aviation industries. All these different parameters and constraints have to be integrated in the planning of processes and structures.

- Products are increasingly *customized*, e.g. in the automotive industries (mass-customizing-strategies). Lead times should be kept at a minimum and change requests after purchase order should still be possible shortly before delivery date. Promised delivery dates have to be met. This implies a stronger focus on *build-to-order-strategies* in production processes in a greater number of market segments. Beside this, customer standards and service requirements are constantly increasing.

Moreover the stagnation of established markets and the shrinking margins call for higher *cost efficiency* within all processes. Here an efficient logistics planning can considerably contribute at an early stage. Along with purchase, production, and distribution planning logistics is going to become a coequal planning object in all companies and therefore we can state, that the importance of logistics planning will increase significantly.

2 Logistics planning requirements

In order to control the network complexity future logistics planning has to be looked at *process-oriented* as well as *structure-oriented*. Logistics planning also does not only focus on single locations, in fact it takes place globally and network-oriented. Efficient logistics structures and processes ensure customer demand fulfillment considering requested availability and delivery time at minimum costs. For the organization this implies a higher profitability and an important advantage over competition. The ideal version is a *collaborative* (and *simultaneous*) *planning* of all network partners at every location.

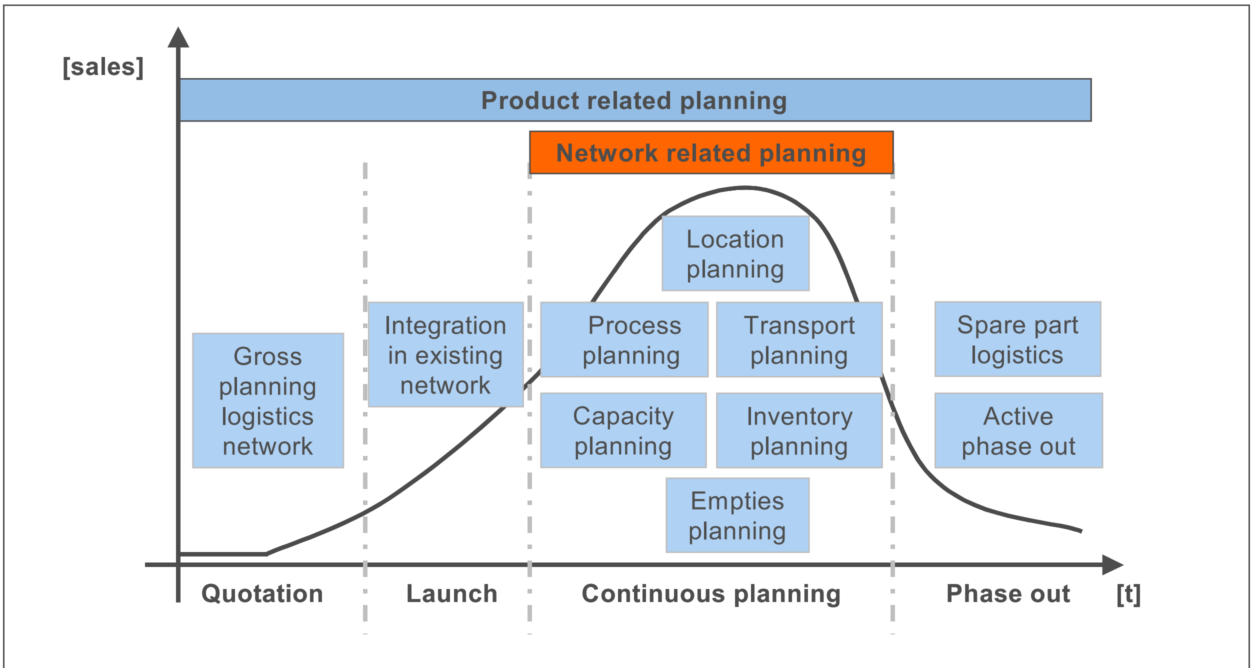

Figure 1: Continuous logistics planning across the entire product life cycle

Furthermore shorter product life cycles require continuous, *flexible* and *fast logistics planning*. It must be able to model different scenarios within a very short timeframe to be in the position of drawing comparisons and making profound decisions in every stage of the planning process. Today a product launch is usually planned like a project. Assumingly future logistics planning is characterized by a standardized planning process on a common database in order to minimize the necessary planning efforts. This ensures the data consistency from product development to purchasing, production, distribution and after sales services. In addition to that the *reverse logistics* must become integrated, e.g. in automotive industries to handle end-of-life-vehicles as required by law within the European Community.

In the course of a survey conducted by the *Rheinisch-Westfälische Technische Hochschule* (RWTH) Aachen (Germany) in 2002, 240 companies from manufacturing companies, retail companies, consumer goods industry and logistics service providers were addressed. The result of the census shows a predicted general increase in logistics costs from 4,9 percent of total revenue in 2001 to 5,6 percent in 2006, that means an increase of about 14 percent with in five years. The most important reasons for this development mentioned in the survey are the following:

- Shorter product life cycle and time-to-market
- Increase of new product developments
- Stronger customer integration
- Rising cost pressure and competition
- Proceeding globalization
- Selection of production sides and distribution systems
- Shift of core competences and increasing supplier integration
- Increasing number of new products and variants

At the same time the *logistical complexity* is expected to be rising massively during the next decade (see Fig. 2). In order to counteract upon this increase the companies will raise their capacities in the field of logistics planning by 26%. To realize this objective the companies need efficient software tools to design and handle global network structures. One of these is the 4flow vista tool for logistics planning in automotive industries that will be introduced in the following chapters.

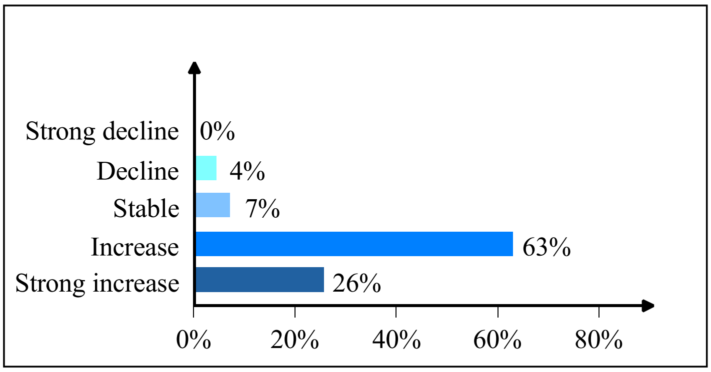

Figure 2: Increase of logistics complexity (2001 to 2011)

3 Basic concept of the 4flow vista tool

The 4flow vista tool is the only standardized software solution for an integrated support of all logistics planning tasks, especially in the automotive industry. Making use of this *decision support system* (DSS) logistics planner are enabled to flexibly map various planning scenarios (see Fig. 3). Although to guarantee for complex network planning a continuous consistency of the planning process is a crucial problem, but it is solved efficiently with this tool. So 4flow vista ensures the consistency throughout all levels of the network as well as the consistency concerning the detailing levels.

Major objectives of logistics are the *cost reduction* and the *increase of service levels*. The costs mainly consist of material, inventory, production, warehousing, picking, handling and transportation costs. The service level includes lead time, ability to supply, delivery reliability, delivery

quality and scope of delivery. Here capacity restraints must be taken into account. In order to achieve these goals the concept of *supply chain management* (SCM) is applied. SCM includes four key elements:

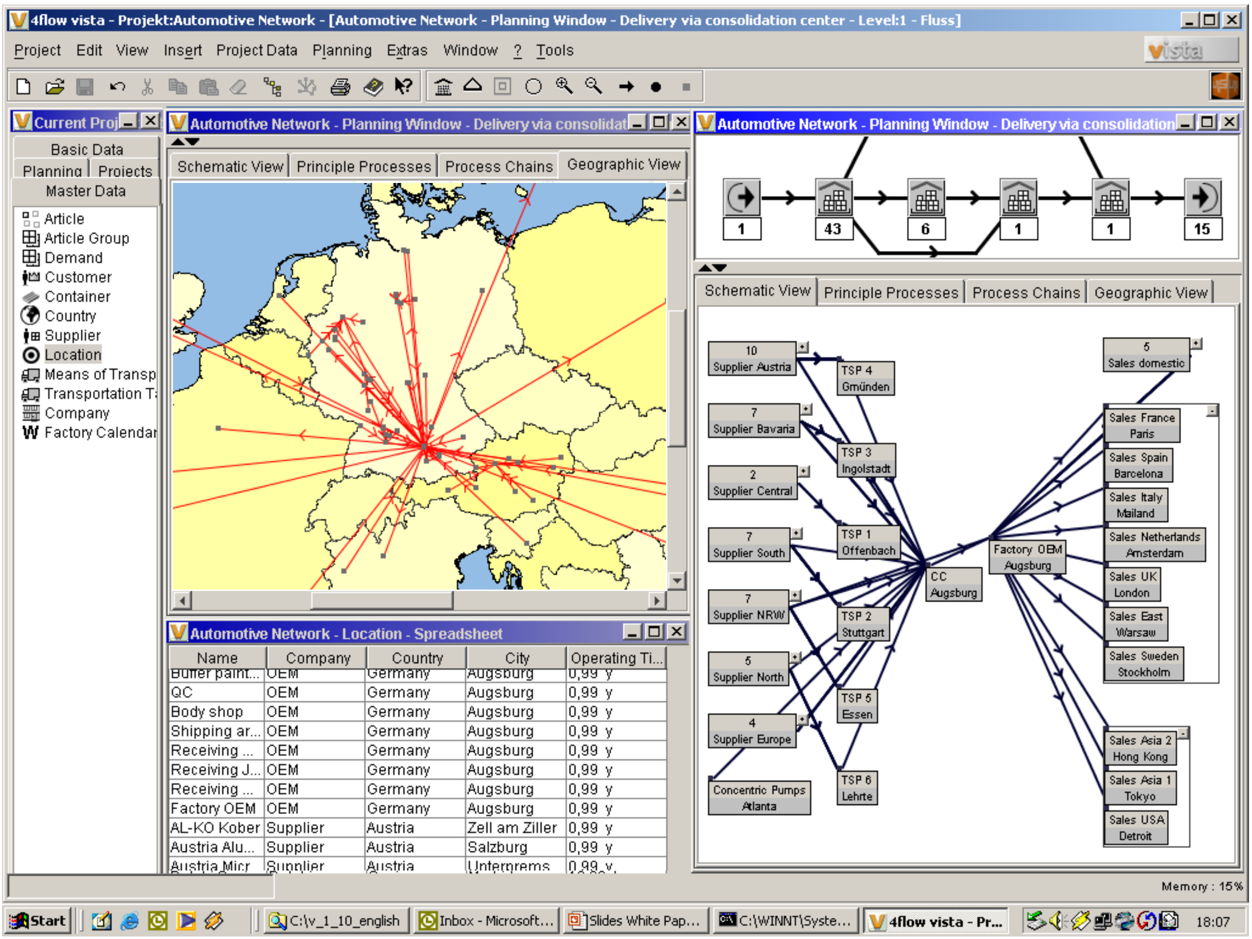

Figure 3: Planning in various views

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- Supply Chain Design: The shaping of structures and processes
- Supply Chain Planning: The continuous planning of sales and production
- Supply Chain Execution: The execution of all logistics processes
- Supply Chain Monitoring: The supervision of the actual state in the network

The 4flow vista tool is used to solve (long-term) strategic planning problems (see Fig. 4), especially in supply chain design and also in supply chain planning.

Due to the long-term decisions about structures and processes a *supply chain design* supported by this DSS-tool has a high impact on the overall concept. Since up to 80 percent of SCM-cost evolve during the supply chain design phase, this stage is of striking importance. In all later phases costs and services can only be influenced on a limited scale and with disproportionate efforts.

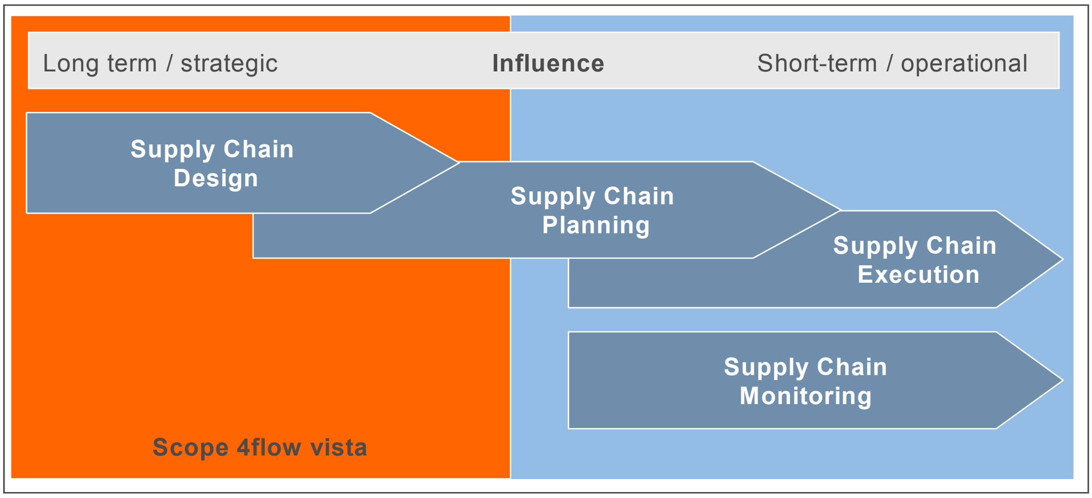

Figure 4: Integration of 4flow vista in the concept of supply chain management

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The entire design of *physical processes* and *structures* of *logistic networks* takes place on several levels. Starting from a complete (global) network, the planning of particular locations as well as certain functional areas, such as goods receipt, production and storage areas, picking and shipping, might be required. These planning levels exist and can be mapped in various views (s. above).

The 4flow vista tool offers flexibility for planning-case specific applications such as:

- Planning levels can be self-defined and interlinked.
- Chosen parts of networks, for instance locations or functional areas, can be chosen and viewed in detail.

A basic structure of the planning levels is shown in figure 5.

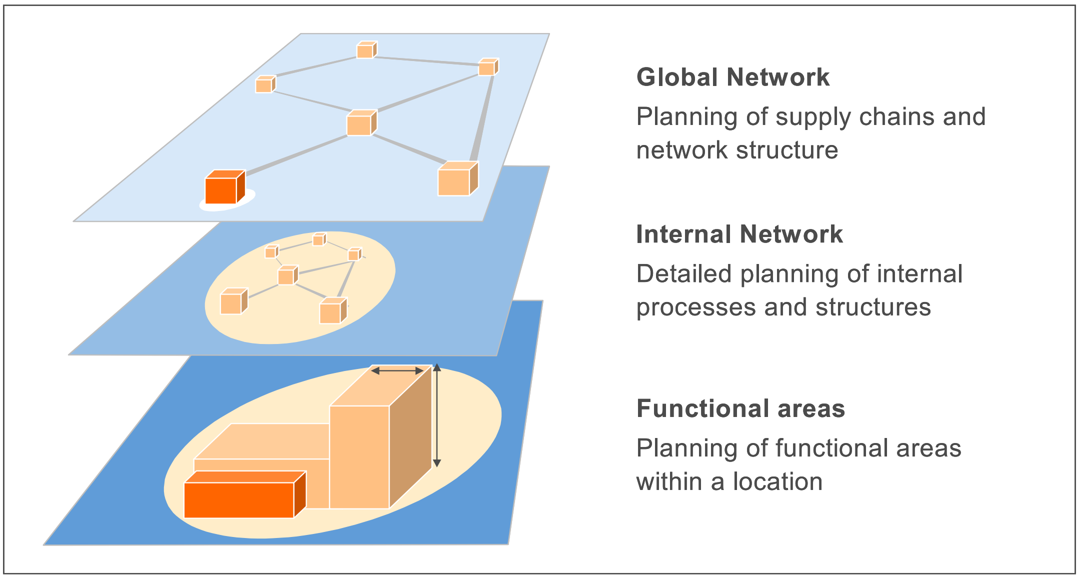

Figure 5: Planning levels in 4flow vista

Any planning project starts by defining the planning objects and the planning objectives. Subsequently the user can start designing the networks in various scenarios to get analyzed and processed different logistics alternatives. They serve as a basis for the decision on possible network structures and processes that shall be realized. An important point is a standardized the design of networks, so that several planners can work on the same project simultaneously. The planning is derived from a common database while defined interfaces can be used for the data gathering. Compared to conventional planning the time effort is reduced enormously while at the same time the quality of the results is improved. Furthermore the employment of different (other) planning tools is prevented.

4 Added value for your organization by using 4flow vista

The 4flow vista tool supports logistic planners in all fields across the whole product life cycle. In the following regularly occurring logistics planning cases are described to demonstrate the varying functionalities the tool is covering.

4.1 Rough planning of logistics networks in the early product phase

In an early product phase the tool supports the planner in the evaluation of various strategies. Advantages and disadvantages of different alternatives become visible due to the planning based on a wide variety of project-like scenarios. These can be easily modeled in order to make a *preselection* of *alternatives* where detailing should proceed. Thus the planner receives a suitable decision basis for the selection of e.g. *production sites*, *transport relations* and *means of transport*. Only a small number of data is required by the planner to derive reasonable conclusions, so that a detailing of the information can take place in later phases. In order to reduce the complexity of planning *part families* are introduced, that consist of logistically similar parts. On the one hand these families reduce the number of planning objects and on the other hand they allow for a planning of automotive networks in the early stage where the final variety of article codes is not yet available.

On the network level, tiers and the number of locations at every tier, are specified. Locations and their connection by transports are designed and visualized, while networks can have any number of locations and transport relations. The planner can optionally use a different view as shown in figure 6. Besides the *geographic view* the network planning can take place in the *schematic view* as well as on the basis of *process chains*. Changing the views is possible at any time. Especially in the case of multi-tier networks the schematic view is extremely valuable, since different stages of value adding can be effectively visualized.

4.2 Detailed planning of locations

Very often the planning on *network levels* is insufficient for selected sub-networks and locations. A detailing is required in order to better detect the production, warehousing, handling and supply costs as well as necessary investments. The 4flow vista tool allows the detailing of locations by modeling an *internal network*, e.g. of a production site. This network is characterized by functional areas and internal transport relations (see Fig. 7). Besides receiving and shipping areas other functional areas such as production, assembling, warehousing or picking can be mapped. Flows of goods from the network level are automatically forwarded to the location level. The relevant cost rates can be specified for each functional area and the detailed costs of a location are automatically forwarded to the planning on the network level.

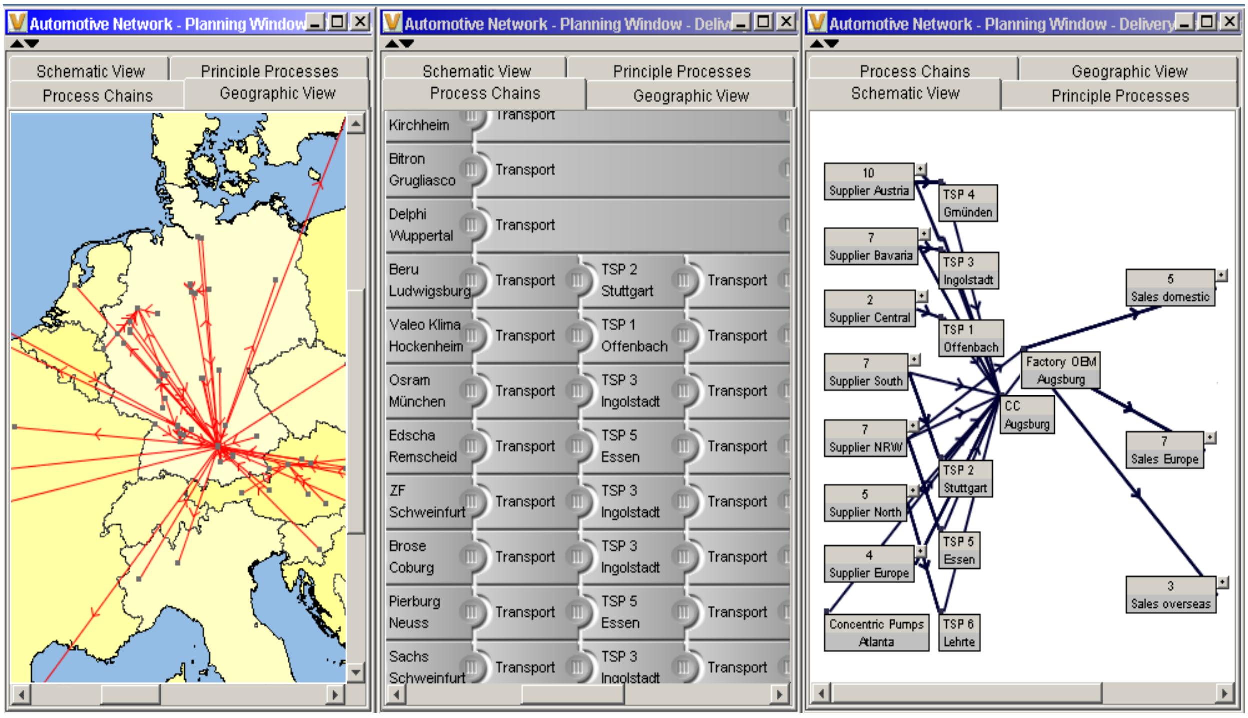

Figure 6: Visualization of locations and transports and processes in the various views

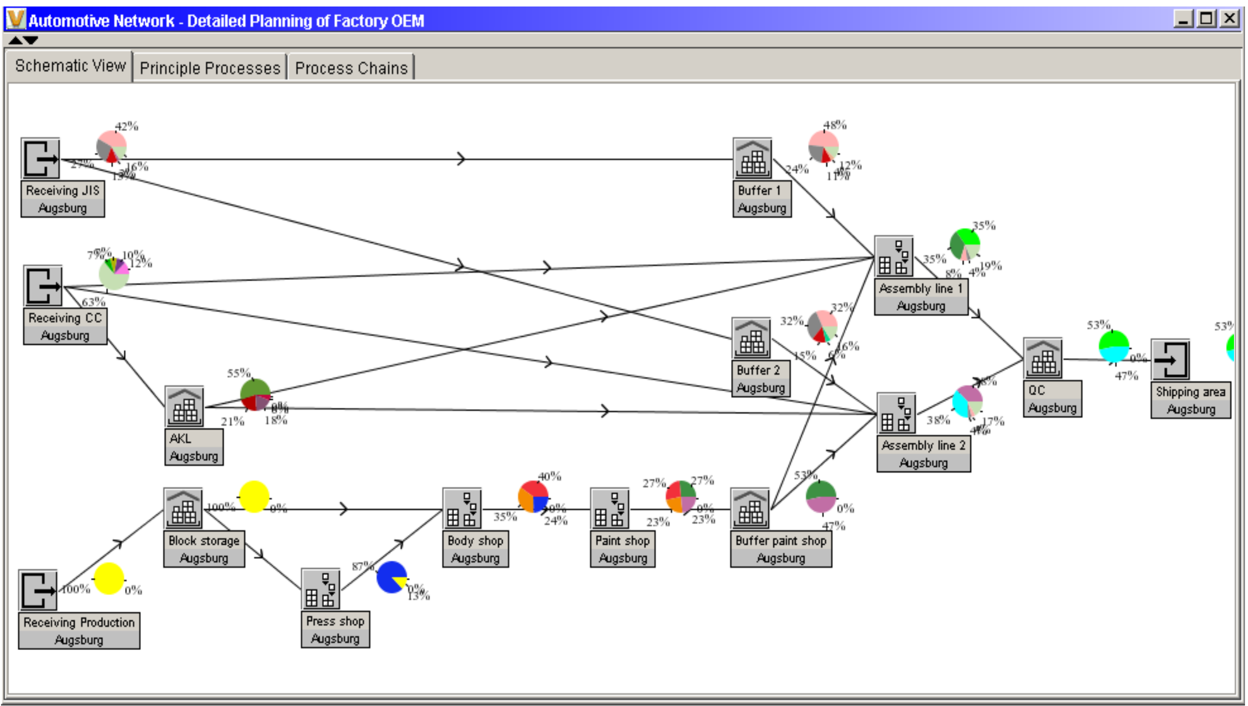

Figure 7: Internal network

Special focus is required by those production and assembly areas within internal networks where incoming part families differ from outgoing families. Therefore in this DSS-tool *bills of material* are applied to define the composition of a family of finished goods. This enables the mapping of *multi-tier production* networks in the automotive industry. In addition the planner can determine the logistics costs per finished good at the different locations.

The tool also includes a *factory calendar* that allows to specify the number of actual working days per month at each location. Regional-, country- and company-specific working schedules and holidays can be taken into account and daily (personal) demands can be determined. This enables the planner to identify costs, throughput and capacity utilization at the location on a real basis.

Further deepening of the planning leads to a detailing of the functional areas defined in the location planning. Based on throughput and inventory requirements of a specific parts family functional areas are dimensioned. Relevant sub-processes are split into single activities, which are administered and stored in a (electronical) library. For comparable sub-processes the stored activities can be used. By allocating staff and other resources, such as space, costs and necessary investments are generated for every activity. Operating costs per process as well as cost drivers can be derived.

4.3 Process planning

In order to identify *process costs* and *throughput times* as well as to compare process alternatives it is necessary not only to model the network structure but also to plan the processes. This is due to the high process orientation in the field of logistics. Therefore the 4flow vista tool integrates the planning and analyzing of individual processes into the network planning. Comparative cost analysis of process chains (see Fig. 8) are also provided making use of the tool.

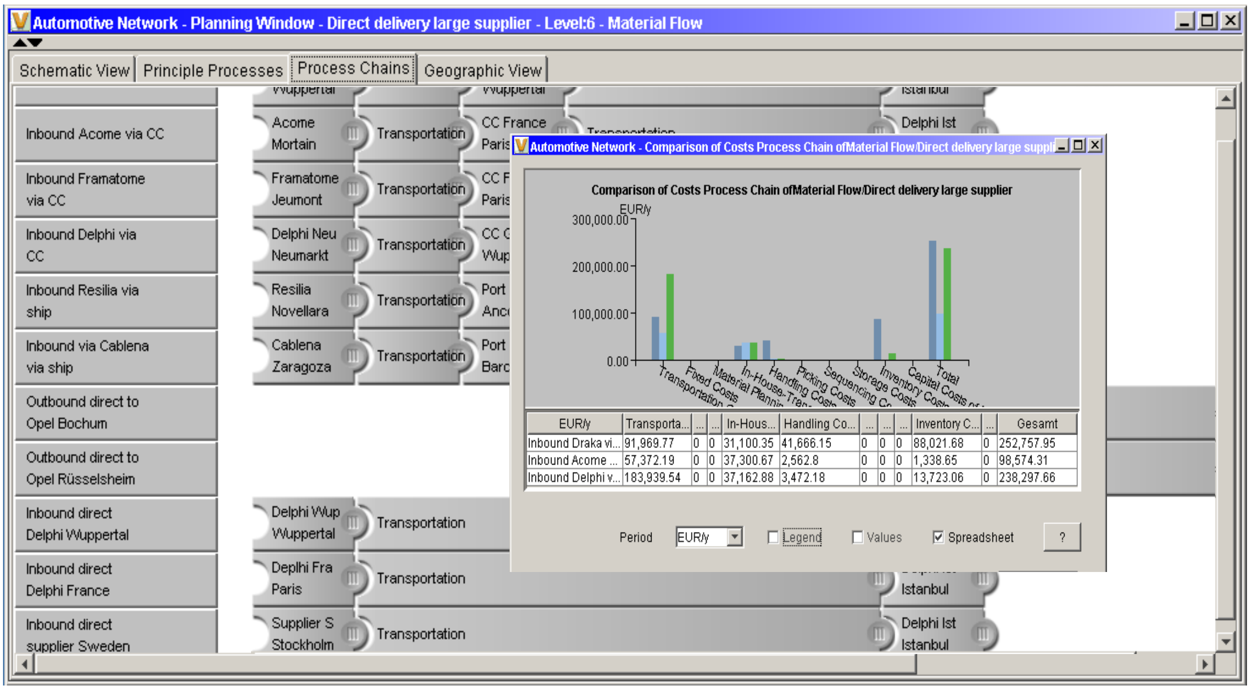

Figure 8: Comparative cost analysis of process chains

The detailed *supply* and *allocation planning* is of striking importance in the automotive industry. Processes from supplier to assembly have to be planned according to strategies like *just-in-time* (JIT), JIS or delivery via external supply centers. Production and assembly plans are developed based on known or forecasted sales data in order to deliver the guidelines for the supply and allocation planning.

In the external network the processes for the relevant part families from supplier to the plant are planned. Within existing networks the tool can consider *interdependencies* with *existing procurement processes*. In the internal network the processes are further planned according to their specific location. Here the supply costs are disclosed across the whole process chain and several network levels.

Part families are transported and stored in different *loading equipments* within the supply processes. In the 4flow vista tool different types of loading equipment can be combined. Furthermore switching between the equipment types is possible. This nesting is especially necessary if for example parts are transported and stored in small boxes, which are then combined on a pallet. The capacities of the loading equipment are specifically given for each part.

4.4 Capacity- and inventory planning

Warehousing and *inventory* costs are crucial parts of the network costs. Due to the integrated planning approach the 4flow vista tool enables the detailed modeling of these costs. For each location the capacities for different warehouse types can be defined and compared in scenarios (see Fig. 9).

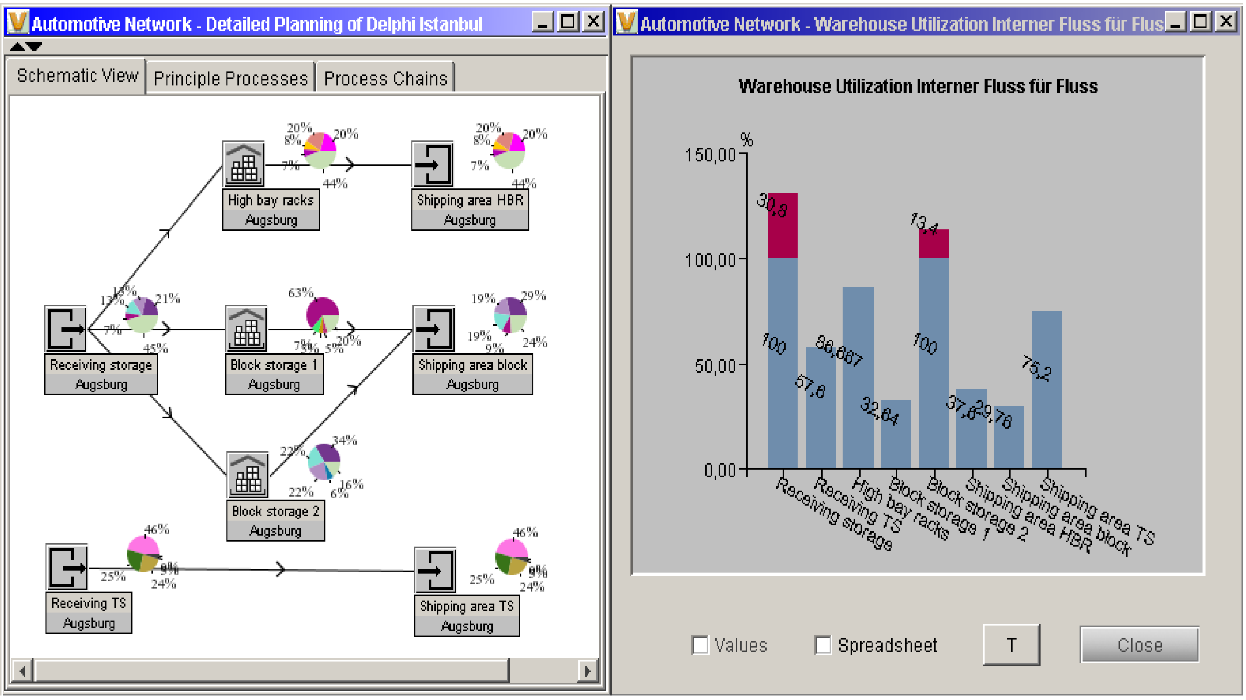

Figure 9: Analysis of capacity utilization for functional areas

For each part family the *inventory* is determined according to the saw tooth model via the safety range and a frequency-dependent fraction. Inventory costs result from the inventory value and company-specific interest on capital. Furthermore throughput capacities, i.e. goods receipt, as well as production capacities can be modeled. Depending on the volume flow chosen the utilization of a warehouse, the production or the throughput is determined. In order to allocate resources more efficiently the planner can view possible *bottlenecks* or *low utilities*.

4.5 Transportation planning

The *transportation planning* in networks affects all logistics planning tasks as a sub-question. Different carriers are defined for transportation between locations of a network and for the internal transport. In the tool any carrier can be entered with its loading space dimensions, allowed payload and speed.

In modeling the transport relations the planner defines the means of transport used, their frequency and the underlying tariffs based on shipping price systems. Furthermore the transit inventory is taken into account by the resulting transportation costs. Apart from the mere transportation volume the weight, the dimensions and the stackability of the means of transport are considered for the calculations of loading space utilization.

Often the logistics planner faces *complex* and *evolutionary grown distribution structures* that are usually intransparent and therefore suggest potentials for optimization. This DSS-tool supports planning by visualizing high transportation costs as well as different transportation frequencies and quantities. Based on this decision support the planner can use various scenarios to develop an optimized transportation structure by direct delivery, consolidation or milk-runs (see Fig. 10).

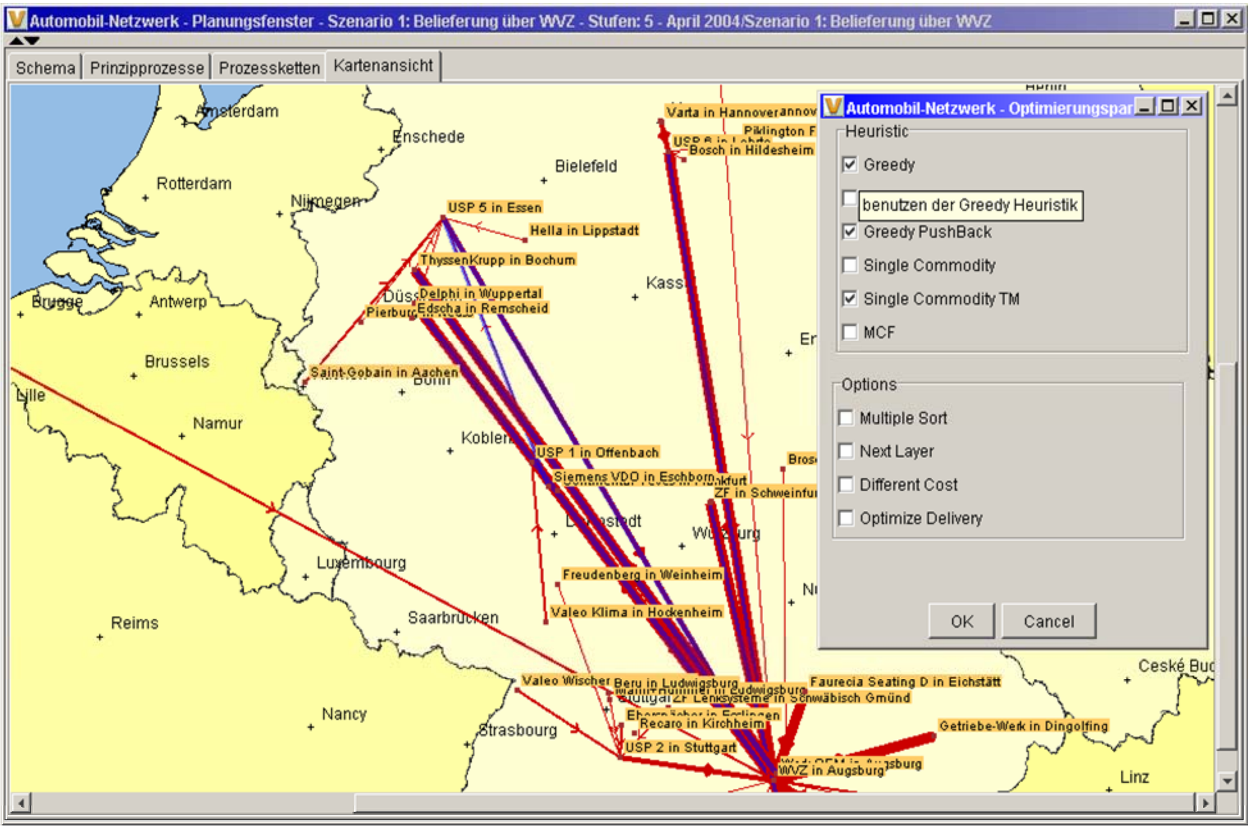

Figure 10: Optimization of selected relations within the transportation planning

Moreover by using the tool transport relations can be automatically calculated by applying mathematical optimization algorithms. In consideration of frequency-dependent inventory costs optimal means of transport, transportation tariffs and frequencies are determined. Furthermore the appropriate milk-runs within a defined supplier region are identified. The combination of incoming and outgoing transports creates integrated transportation concepts.

4.6 Planning of empties

The application of high value *reusable loading equipment* increases the importance of these processes. *Empties* emerge at the point of use of a part family, in the picking zone, and at the drains when final products of a network are assembled. In contrast it is usually required at the end of production for the transport of the final product family and at the beginning of a picking step.

In the 4flow vista tool the network of empties and the network of full loading equipment are integrated. Additional locations and transport relations that are required because of the management of empties are modeled in the same network. Planning levels of empties and the flow of full loading equipment are identical. The tool allows a differentiation between reusable and one-way loading equipment as well as between different volumes of full and empty loading equipment. One of the key planning results with the DSS-tool is an analysis of the required loading equipment within the entire network as well as of particular locations (see Fig.11). The planner is able to quantify required investments and to identify packaging costs.

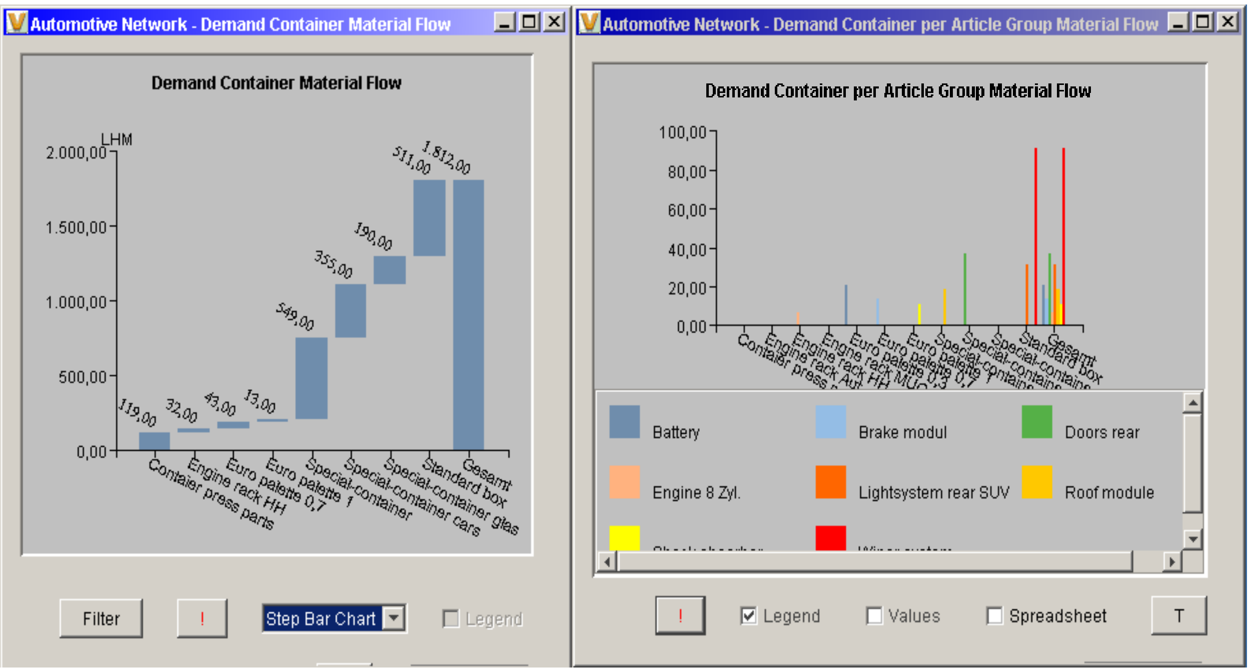

Figure 11: Demand analysis for loading equipment and for selected product groups

4.7 Planning of spare parts logistics

Spare parts are either stocked and distributed in networks differing from the primary product or using the same distribution channels. Additionally, partners like *Maintenance*, *Repair* and *Operation* (MRO) and *overhaul companies* with pooled stocks can be part of a spare part network, which is driven by service requirements. Due to the central data storage the tool enables both scenarios. It furthermore facilitates an integrated logistics planning throughout the whole product life cycle. Auditing and planning of spare parts logistics is particularly supported. Here the planning and designing of the spare parts network can come to the fore. Another focus lies on the identification of cost saving potentials within the processes. The planner has the opportunity to identify bundling effects on reasonable transport relations of the spare parts network and to weigh advantages and disadvantages of bypass deliveries on various relations (see Fig. 12). In addition the logistics planner can check various supplier contracts and compare process costs.

4.8 Planning and evaluating scenarios

The planning of the network can be analyzed according to *different criteria*. The main focus of the analysis is on the following aspects:

- Networks and sub-networks
- Locations and their functional areas
- Network and location processes

The logistics planner can conduct the analysis of these objects for all or selected part families separately. For several identical objects an analysis can also be executed in a scenario comparing mode. Cost comparisons across different planning periods are possible as well as the use of a full cost or a direct cost approach. The spectrum of possible analysis consists of capacity, performance and cost ratios (see Fig. 13).

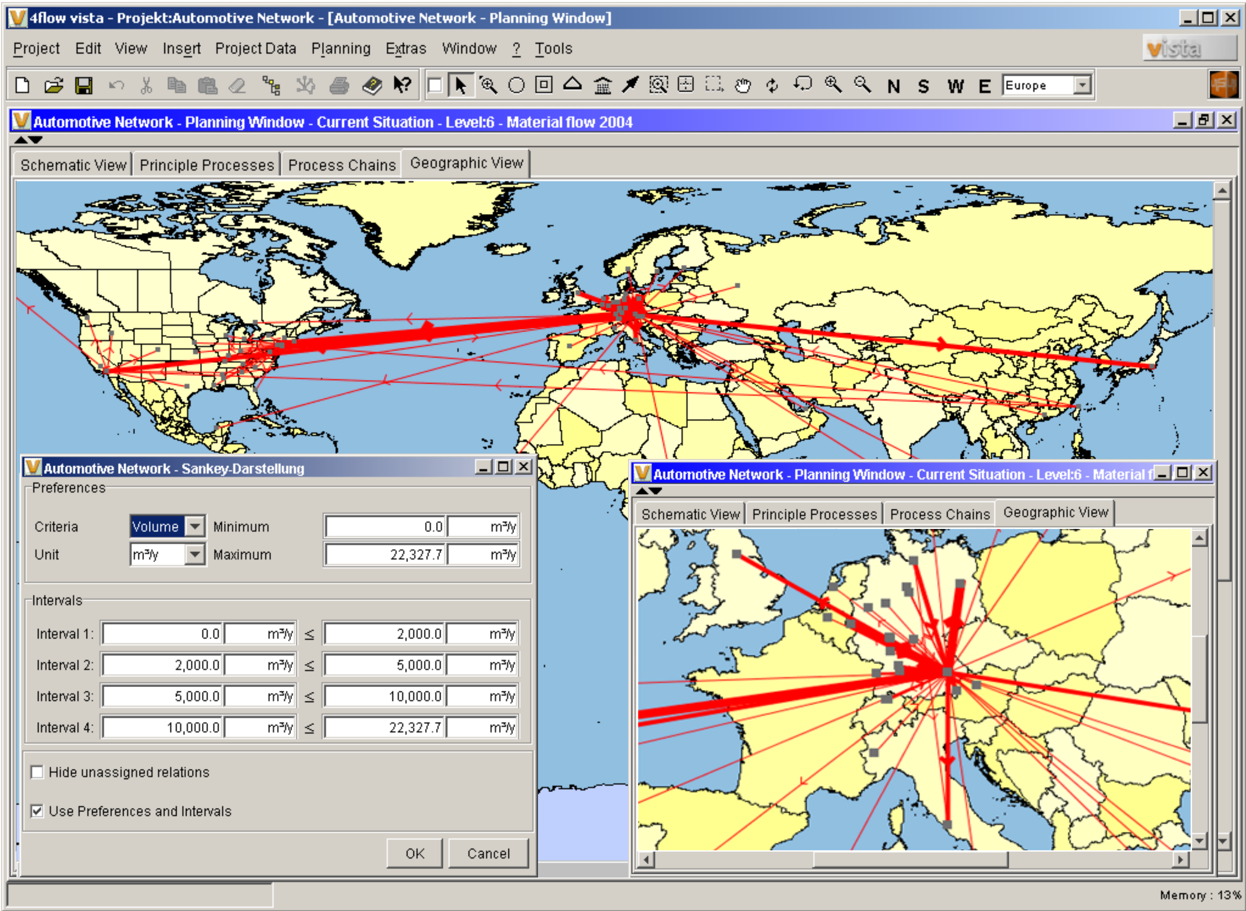

Figure 12: Visualization of volume flows in a global spare parts network

Often the logistics planner faces the task of only analyzing extracts from certain networks. An example would be the transportation costs in the procurement for a selected production site by given service providers. Correspondingly the extensive and user friendly filters allow to analyze the networks and check them upon their feasibility. These filters can be applied in a schematic as well as in a geographic view. This separate or combined filtering according to part families, companies, transport relations, transportation service providers, on the basis of volume flows or for instance by a geographic focus allows the fast determination and visualization of weaknesses of the network. In the automotive industry the visualization of the strength of volume flows is a frequent request. As shown in figure 14 the analysis of volume flows is also possible with a Sankey filter. Furthermore all analysis can be applied on the filtered sub-networks.

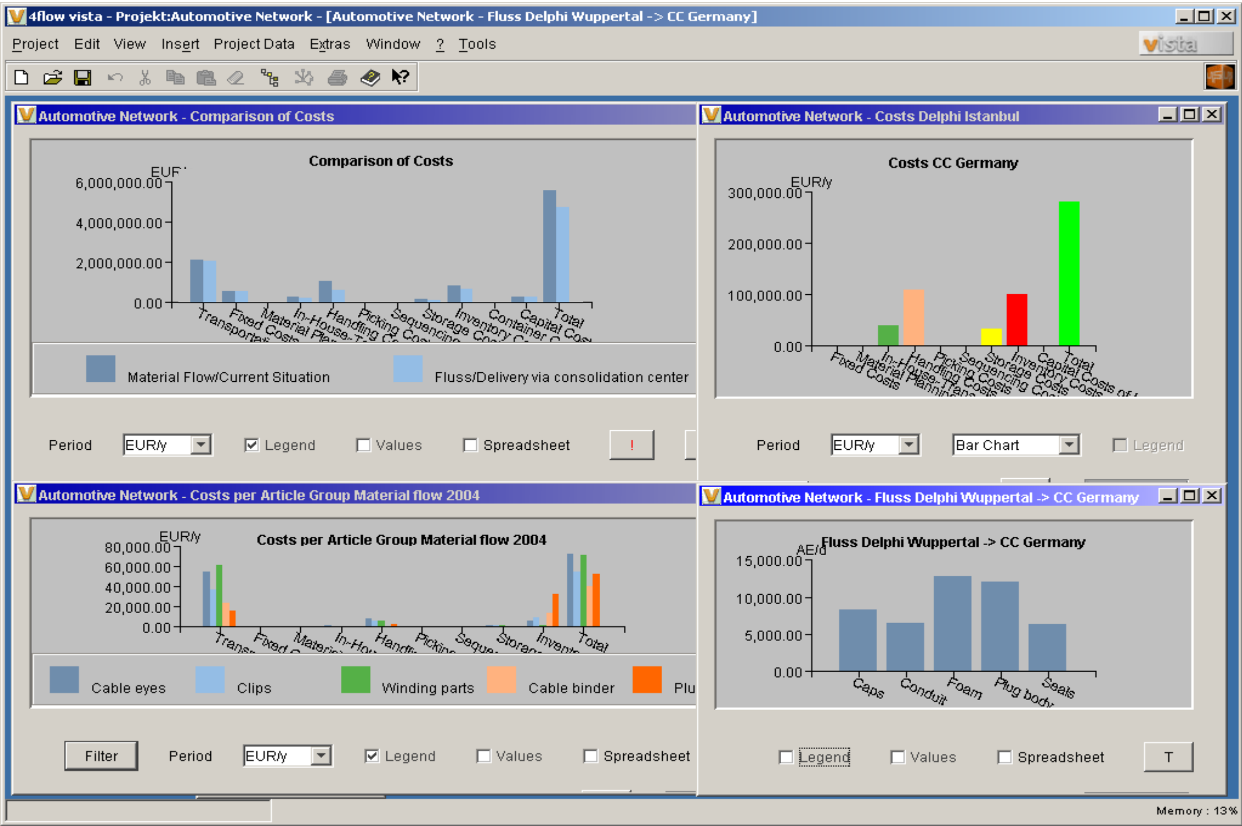

Figure 13: Presentation of various costs and throughput analysis

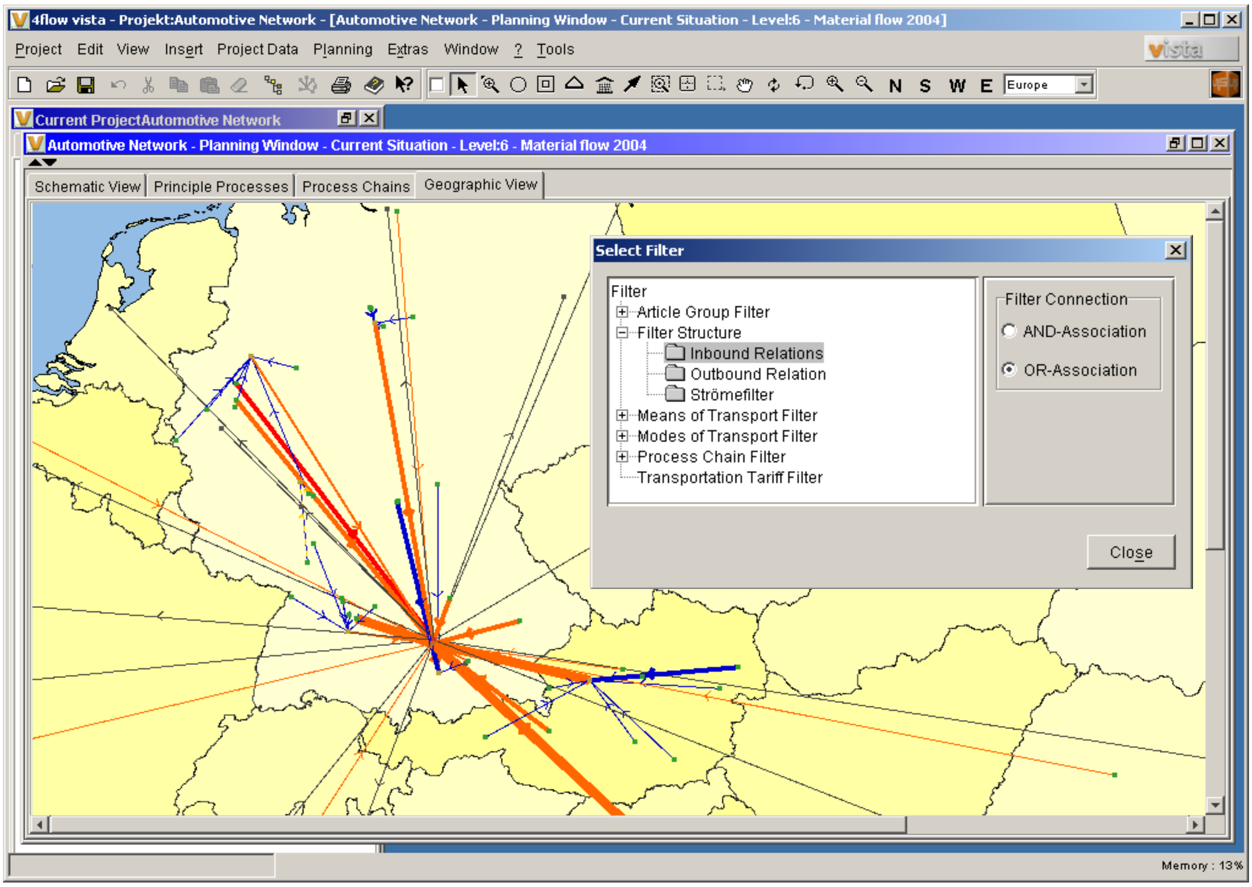

Figure 14: Individually defined filtering of the inbound network of selected locations

5 Potentials by using 4flow vista

The use of the 4flow vista DSS-tool leads to a reduced time effort and to a better outcome quality of network planning. Future challenges of logistics are transforming into major opportunities - an optimized network creates and ensures competitive advantages and thus supports sustainable success for an organization. The changes of the general framework of global operating industrial companies as described above lead to a rising need for designing new networks. The main goals are:

- To lower the costs while improving delivery service quality
- To utilize existing capacity more efficient
- To develop practicable solutions
- To evaluate the sustainability of processes and structures
- To be able to give quick and high quality answers to logistical questions

Conventional proceeding in designing networks reveals great insufficiencies - planning models are very often developed individually by one single planner and are never used again. A further enhancement of those models by a third person implies a detailed explanation. Data collection often occurs only project based and with notable effort. Collected data are only produced once and usually there are no continuous updates. Modeling, evaluation of network scenarios and planning on different levels of detail is quite time consuming.

These gaps are closed by applying the 4flow vista software tool for the creation of (global) logistics networks.

- The tool allows standardized network planning. All planners are using the same methods and algorithms.
- Design, visualization and evaluation of networks is possible in a simple planning process. Planners are in the position to map and evaluate a high number of different scenarios.
- The tool enables planning and optimization on different detail levels. Planning on network levels can be concretized by process- and functional area planning.
- A common database is used, so that all planners are able to work collaboratively on the same planning projects with the same network models.
- The tool allows to reuse existing planning projects, that means planners are able to edit existing planning cases and enhance the existing network models.
- The tool permits a standardized data collection. Using defined interfaces data can be imported from third-party systems and updates can be executed.
- A continuous documentation of the logistics processes and models is possible.

Applying the 4flow vista tool a significant reduction on manual tasks in a supply chain design processes can be attained, especially using it for the first time. Due to the automatic adoption of master data the economies of scale - for example in generating data - are considerably increasing if additional projects are planned. Another advantage lies within the continuous logistics planning. Compared to only replanning a network every four to five years the continuous planning leads to a considerable decrease in logistics costs.