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Integration of Velos-Simulation-Results into the Supply Chain Balanced Scorecard

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1 Introduction

The subproject M3 of the Collaborative Research Center 559 has been working at the field of network controlling of large logistics networks since 1998. Firstly, for this purpose, requirements on such a network controlling had been developed within the subproject. Secondly a conception had been designed, which is qualified for cost input and cost allocation in a network and which is able to investigate the suitability of existing instruments respectively. The conception should also enable the transfer of cost information within the network as well as function as a supporting instrument for the cost management.

Based on these demands the Supply Chain Balanced Scorecard has been developed as a controlling conception for planning, regulating and controlling large logistics networks. The conception is described detailed in chapter 2.

The goal of the collaboration is to exemplify the implementation of the Supply Chain Balanced Scorecard. Therefore, a model of a transport network is specified, which has been constructed with the simulation-tool VeloS, to point out the integration of selected operating figures of the model and respectively the planned simulation into the Supply Chain Balanced Scorecard. The model and the simulation are described in chapter 3 so that subsequently in chapter 4 selective Key Performance Indicators (KPIs) can be integrated into the SC Balanced Scorecard.

2 Supply Chain Balanced Scorecard

The Supply Chain Balanced Scorecard can be regarded as a further development of the classical Balanced Scorecard for networks by *Kaplan/Norton*.[1] The four classical perspectives such as Financial Perspective, Customer Perspective, Internal Business Processes Perspective and Learning and Growth Perspective are suited to the requirements of networks. Besides a fifth perspective is added so that the new perspectives called Financial, Resource, Process, Market and Cooperation Perspective result (Figure 1).

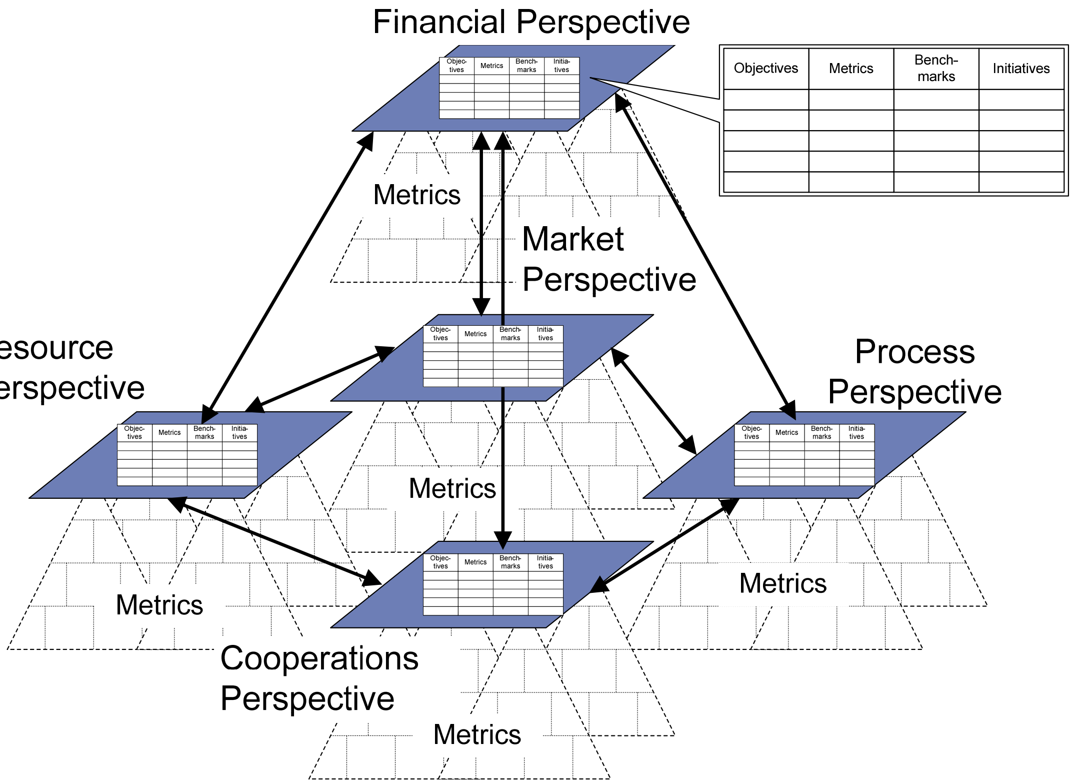

Figure 1: Supply Chain Balanced Scorecard[2]

The **Financial Perspective** is acquired from the classical Balanced Scorecard and performs a double function. On the one hand it contains metrics for the financial performance and on the other hand it is the ultimate point for all chains of cause and effect which base in the other perspectives.[3]

The **Resource Perspective** includes all key figures which specify the consumption of potential capability. The main focus in this context is to highlight optimisation potential in the consumption of resources and capacity utilization.

The **Process Perspective** can be seen as an upgrading of the classical Balanced Scorecard because it no longer includes intra-corporate processes but cross-company processes. Furthermore the Customer Perspective has been replaced by the Market Perspective so that the end customer and the competitors of the supply chain can be regarded.

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[1] See Kaplan/Norton, 1992.
[2] Adapted from Jehle et al., 2002, p. 21.
[3] See Kaplan/Norton, 1996, p. 47.

Finally the **Cooperations Perspective** acquires all key figures which affect the cooperation of the supply chain partners. The goal is to point out indicators which enable to identify a win-win-situation for all participants.[4]

The procedure of the practical implementation can be divided into several steps: According to the specific supply chain aim or a particular strategy four to seven suitable key figures are chosen for every perspective. Afterwards the dependencies of these metrics, which can be described by chains of cause and effect, are verified. Besides concrete objectives and benchmarks can be specified. After the data appraisal and the identification of interactions between the metrics the appropriate actions to achieve the aims can be pointed out.

4 See Jehle et al., 2002, p. 22.

3 Modelling and Simulation of Logistics Networks

3.1 Basics of Logistics Systems

Governments all over the world are interested in both: internal and international trade and transportation. This has many reasons. It is believed generally that each country produces in that sector, in which it is the market leader. Then it is able to trade some of its surpluses for goods or services that other nations can offer. All nations would like to export more than they import, in order to generate a positive balance of trade, which helps bolster both the country's currency and employment.[5]

In order to obtain a benefit from transportation of goods over the world, or between the basic nodes inside a trade network was evolved a particular science called Logistics.

Logistics is a science about planning, organizing, management, control and regulation of movement of the material and information flows in space and time from their primary source up to the end user.

3.1.1 The Object of Research

The objects of logistics research are material flows and, connected to them, information flows. The motivation and increasing interest to its research are caused by potential opportunities of growing efficiency of transportation systems' performance.

Logistics essentially allows reducing the time interval between purchasing raw materials and semi-finished products respectively delivering a finished product to the consumer. It enables to reduce material stocks, accelerates the process of gathering information, and also raises the service level.

The function of logistical systems is characterized by complex connections inside the system and its connections with an environment.

3.1.2 Subsystems in Logistics Networks

A logistical system is an adaptive system with a feedback that realizes especial logistical functions. It consists of several subsystems and has close relationships with its environment.

The following subsystems can exist inside a large logistics network:

1. Purchase Logistics:

   At this stage a responsible department selects the suppliers, closes contracts, supervises the execution of signed contracts, and finally measures performance indicators in case of infringement of delivery conditions.

2. Industrial Logistics:

   The sphere of industrial logistics is closely connected to spheres of purchasing materials and distribution of finished goods. However, the basic circle of problems in this area is the management of material flows during the process of manufacturing.

3. Distribution Logistics:

   It solves a wide circle of problems, which concerns containers and packing, the size of a made party and time to which this party should be prepared, and also many other aspects which are essential for a process of realization.

[5] See Wood, 2002, p.14.

4. Transportation Logistics:

   Its primary objective is the process of delivering the material flow from a primary source up to the final consumer. The term “deliver” characterizes the activity by its output. All operations refer to every process, which is connected to goods, information and finance in order to affect this outcome.[6]

5. Information Logistics:

   Results of movement of material flows depend directly on rationality of organization of the information flows. Thus, the object of research are the information systems, which provide the management of material flows, using microprocessor techniques, and information technologies.

3.1.3 Appliance and Usability

The Limitation of logistical systems are defined by a cycle of movement of means of production.

First the investment goods are bought from suppliers. As a material flow they are entered into a logistical system. Afterwards, they are stored, processed, stored again, and finally they leave the system with consumers in exchange for financial resources incoming into the logistical system.

The industrial enterprise, a production complex, trade enterprise, etc. can be regarded as logistical systems. The purpose of a logistical system is to deliver goods and products to the defined place, in the demanded quantity and assortment, in the greatest possible degree prepared to industrial or personal consumption by the set level of costs.

Logistic comprises all the operations which are needed to deliver goods or services, except producing the goods or performing the services. In manufacturing, it covers the material flows between plants and between production lines within a plant. It also includes the information flows generated by the processing of transactions associated with the material flows, the analysis of past activity, forecasting, and the planning and scheduling of future activity, as well as the financial flows triggered by the movements of goods and information.[7]

How can we estimate and increase the efficiency of a logistical system?

The efficient and effective movement of goods from raw material sites to processing facilities, component fabrication plants, finished goods assembly plants, distribution centers, retailers and customers is critical in today’s competitive environment.[8]

3.2 The Modell

3.2.1 VeloS - A Tool for Modelling and Simulation

The chair of transport and logistics, University of Dortmund, has recently developed a simulation environment (VeloS – Verkehrslogistische Simulationsumgebung) for modelling information flows, material flows and transport operations in logistical networks (e.g. distribution networks, transportation networks) and in logistical nodes (e.g. distribution centers, transshipment terminals). VeloS is based on the simulation software Enterprise Dynamics developed

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[6] See Baudin, 2004, p.10.
[7] See Baudin, 2004, p.7.
[8] See Langevin/Riopel, 2005, p.39.

by Incontrol which has been enlarged by several routines to enable the modelling of all aspects of distribution.

By using the simulation tool VeloS it is possible to test the effects of long term and operational strategies / decisions in a simultaneous model. The strategies or decisions can refer to the network level (e.g. type of network, number and location of terminals, time-table for transport) as well as to the terminal level (layout decisions, optimal operational dispatching strategies, number and type of resources). After having built the model, several performance indicators (e.g. throughput for each time unit, investment and operational costs) can be observed and the effects of changes can be analysed to find best strategies or decisions.

The simulation tool VeloS was first used for modelling a LTL (less than truckload) terminal of a medium-sized forwarding agency.

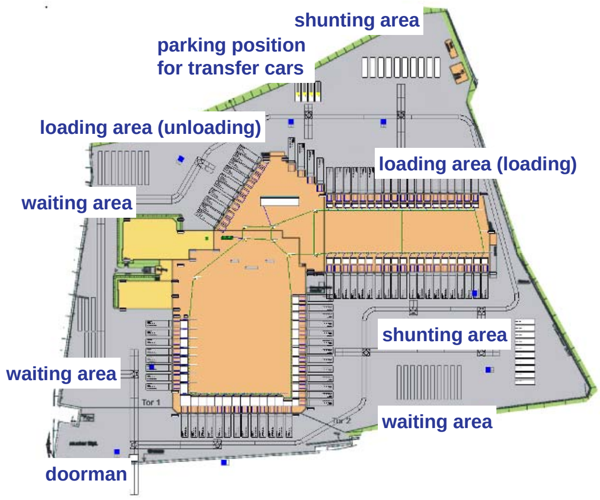

Figure 2: Model of a LTL forwarding agency

The model is used for optimizing the decisions in dispatching and identifying bottlenecks. By analysing the throughput it is possible to determine the maximum performance in the LTL terminal based on different operating strategies.[9]

The combination of several logistical nodes to a network can also be simulated with VeloS. The logistical nodes with input-, sorting-, and output-capacity are subsumed to a modul. The nodes can be connected with edges (streets) to a network (direct-transport-network, hub-spoke-systems). Therefore, both strategical decisions referring to the network (choice of location, routing decisions) and the effects of political developments (toll, fuel costs, driving bans, etc.) on the disposition can be evaluated.

3.2.2 Key Performance Indicators (KPI)

Business performance can be measured in many ways. The recent trend abandoned from simple financial measures such as return on investment (ROI) or earnings per share. Leading companies are moving towards a more rounded set of performance indicators, such as represented by the Balanced Scorecard.

Key Performance Indicators (**KPI**) are financial and non-financial metrics used to quantify objectives to reflect strategic performance of an organization. KPIs are used in Business Intelligence to assess the present state of the business and to prescribe a course of action. KPIs are metrics, such as the benefits of leadership development, engagement, service, and satisfaction, which often are very difficult to measure. KPIs are typically tied to an organization's strategy (as exemplified through techniques such as the Balanced Scorecard).

[9] See Neumann, 2007, p.3 ff.

3.2.3 Selection of KPIs

Key Performance Indicators are quantifiable measurements, agreed to beforehand, which reflect the critical success factors of an organization. They will differ depending on the organization or network system. An organization may have the percentage of its income that originates from return customers as one of its KPIs. A school may focus its KPIs on graduation rates of its students. A Customer Service Department may choose in line with overall company KPIs the percentage of customer calls answered in the first minute as one of its KPIs. A Key Performance Indicator for a social service organization might be the number of clients assisted during the year.

Whatever Key Performance Indicators are selected, they have to reflect the organization's objectives, they have to be the key to its success, and they have to be quantifiable (measurable). KPIs usually are long-term considerations. The definition of what they are and how they are measured does not change often. The objectives for a particular KPI may change as the organization's objectives change, or as it gets closer to achieving an objective.

The implied connection between these indicators is that people (cooperation) help (internal process) customers (customer) to affect on business performance (financial).[10] The simulation of a network can help to get the KPIs, which are in case of no simulation perhaps difficult to obtain.

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[10] See Buttle, 2004, p.2.

4 Integration of the simulated KPIs into the SC-BSC

4.1.1 Selection and Integration of the KPIs into the Perspectives

The KPIs which can be customized for the each logistics system include:

- Financial
    - Transportation costs
    - Expenses for damaged and lost goods
    - Handling costs
    - Costs of warehousing
    - Return on investment
    - Economic value added
- Customers
    - Value proposition
    - Geography of orders' location
    - Pricing method
    - Market share
    - Customer retention
    - Customer satisfaction
    - Percentage of permanent clients
- Internal processes
    - Delivered on time, in full, no damage
    - Cycle time
    - Fuel rate
    - Idle time of vehicles by handling
    - Turnover ratio of storehouse
    - Index of effective mileage
- Resources
    - Percentage of useful storage space
    - Degree of lifting-and-shifting machine utilization
    - Average storage time in warehouse
    - Employee satisfaction
    - Employee productivity
- Cooperation
    - Employees cross-trained
    - Quantity of established good relations with suppliers
    - Terms of agreements' validity
    - Average and ultimate time of order processing

Figure 3 shows how these KPIs are integrated into the SC-Balanced Scorecard and how the KPIs are connected with each other over the five perspectives with chains of cause and effect:

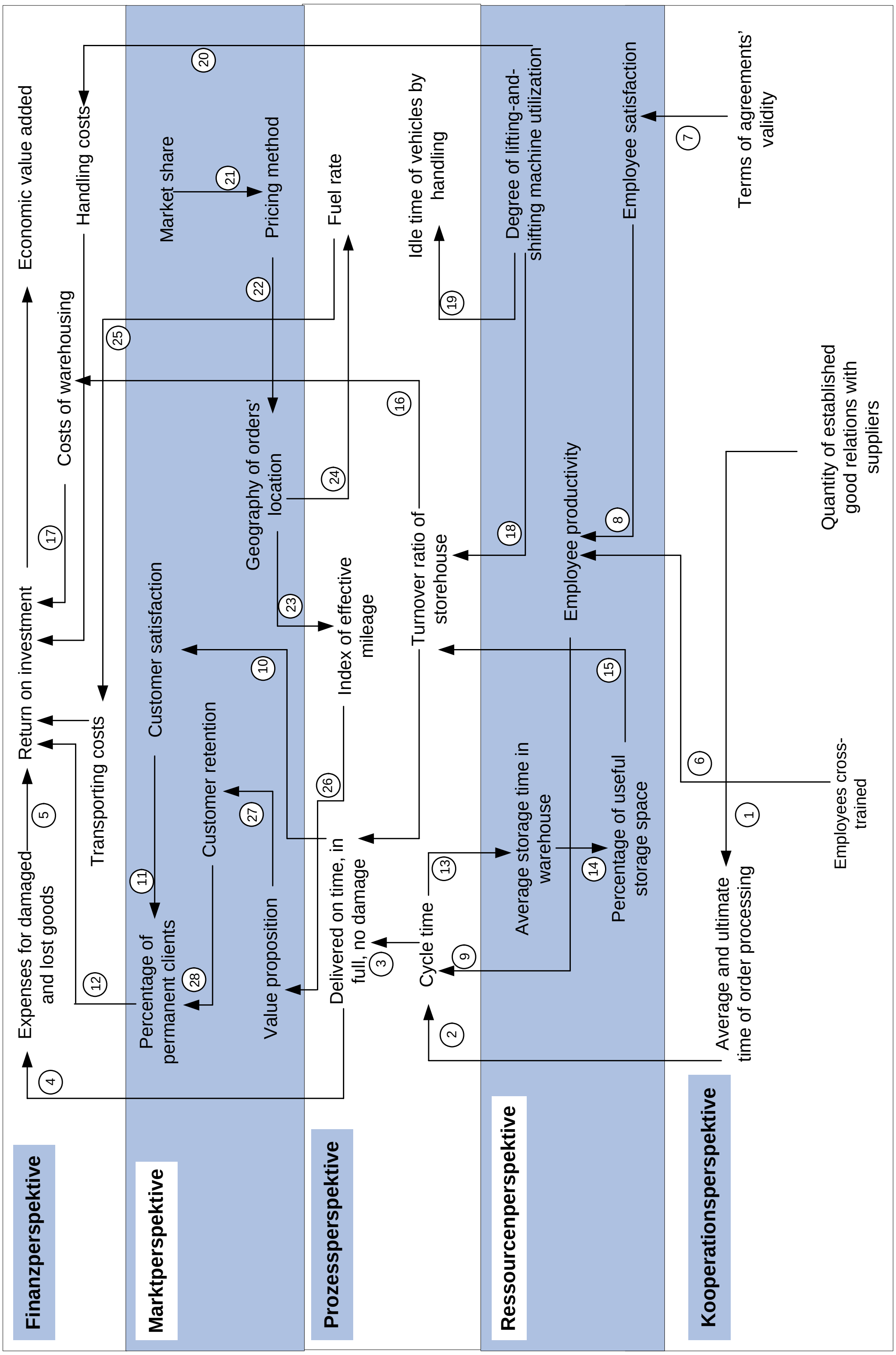

Figure 3: Example for the SC-Balanced Scorecard

4.1.2 Chains of Cause and Effect

The quantity of established good is related to suppliers' raises average and ultimate time of order processing **(1)**. The closer interactions with suppliers are, the faster the order of a customer will be processed. This causes an influence on the cycle time of a process (**2**), and in the following on the products' on time delivering **(3)**. If there were few loss or damages during transportation **(4)**, the investments return to the logistics company **(5)**.

The cross training of the team and employees' satisfaction (the last is achieved by long terms of agreements' validity **(6)**) influences the productivity of workers **(7,8)**. By a high level of productivity the cycle time of processes is decreased **(9)**. And the quality of accomplished operations such as delivery on time without loss and damage is improved as well **(3)**. The percentage of permanent clients growths **(11)** and investments return to the depositor **(12)**.

In case of a short cycle time, it takes a short time to store goods in warehouses **(13)**, which influences the percentage of useful storage space **(14)** and enhances the turn ratio of a storehouse **(15)**. The turn ratio of a storehouse is also affected by degree of lifting and shifting machine utilization **(18)**. When machines are considerably exploited, the idle time of vehicles by handling is insignificant **(19)** and the cycle time of a process can be increased. Due to the metric of turn ratio the handling costs and costs for warehousing can be estimated **(16, 20)**.

Each logistics company or system covers a separate share of market. The share of market and price method **(21)** influences the geography of delivery points **(22)**. The geography of delivery points regulates the fuel rate **(24)** and transporting costs **(25)**. However, if the routes and schedules are planned well, the index of effective mileage is optimal **(23)** and expenses for goods transmitting are beneficial for a client **(26)**. This enhances such metrics as customer retention **(27)** and percentage of permanent clients **(28)**.

4.1.3 Perspectives of KPIs Integration

Various studies have shown that companies, which objectively control and monitor their performance by indicators, are more successful than those which do not control at all. If business executives are informed about the performance indicators and the factors that influence them and lead to results, they can make improved and more effective decisions. Control of the performance indicators must, therefore, be directed towards the targets, problem areas and the critical success factors. The resulting advantages are as following:

- Improved achievement of objectives
- Improved and faster decision making
- All employees are aligned to common objectives
- Managers and employees have greater confidence and motivation.[11]

[11] Poluha, 2007, p.34.

5 Summary and Forecast

The collaboration exemplifies how simulation results can be integrated into the Supply Chain Balanced Scorecard with help of the simulation tool Velos. For that purpose, based on the examination of the particular transport network, selected Key Performance Indicators are assimilated in the five perspectives and their dependencies are illustrated by chains of cause and effect.

After the successful completion of the simulation the Key Performance Indicators have to be specified with concrete data to show their actual impact on the Supply Chain Balanced Scorecard. Based on these results, the chosen Key Performance Indicators can be reviewed and if necessary they can be adapted or substituted. Furthermore, the chains of cause and effect show impacts on the financial Key Performance Indicators and therefore, measures referring to the transport network can be used.

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