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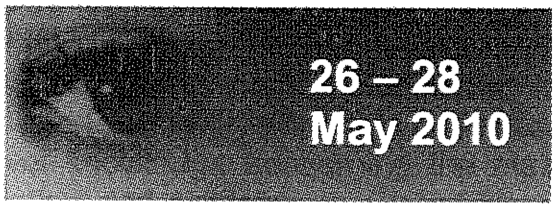

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Concept of transport-oriented scheduling for reduction of inbound logistics traffic

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Abstract

Nowadays ecological issues are of high public priority. In industry and especially the automotive sector, often new machines, facilities or technological innovations are the key to ecological improvements. Although it is seen less prominent, logistics plays an important part to optimize the ecological system. Due to the high amount of transport traffic in inbound logistics, small changes lead to substantial savings in CO_2 emissions. Through transport-oriented scheduling this potential savings can be realized. By means of smoothing and bundling demands in scheduling, transport planning can be optimized resulting in a raised utilization or avoided unnecessary transports resulting in a reduction of CO_2 emissions. The developed concept was evaluated by means of a simulation model using real scheduling data.

Keywords:

Logistics, Planning, Scheduling, Production

1 INTRODUCTION

Over the last two decades, ecological thinking has been increasingly growing in importance in the public eye. This is emergent in the design and technologies of buildings (e.g. low-energy house) or products (e.g. hybrid technology) [1] [2]. This attitude is often driven by high operation costs [3]. On closer examination logistics as well has to adjust their processes according to these changes, in order to reduce not only emissions but also to save costs.

Original Equipment Manufacturer (OEM) in the automotive industry often face unsteady demands due to a high level of customer oriented productions [4] [5]. These fluctuations in demand, especially through low-runner parts, causes several inefficiencies in logistics, i.e. unsteady traffic volumes at good receipt or low utilization, which raise the overall CO_2 emission in the system [6] [7] [8].

In the automotive industry, the supply of material is achieved with two different supply concepts. *Full-truck-load transport* (FTL) is a concept which can be used when demand is constant over a certain time-period. The outcome of this is a high utilization. These transports often deliver high-runner parts and specific supply times are assigned by transport planning. On the other hand, *less-truck-load transport* (LTL) is very flexible and delivers low-runner parts [9] [10].

On closer examination of the transport ratio of FTL and LTL, a high amount of incoming LTL trucks per day can be identified (Figure 1).

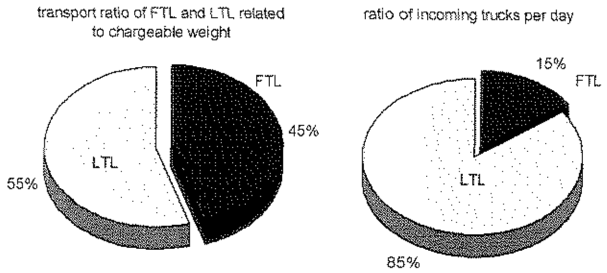

Figure 1: Ratio of Full-truck-loads (FTL) and Less-Truck-Load (LTL).

These transports with their unstable demand for the supplied parts and resulting low utilizations, represent the ideal area to realize a new supplier concept, in order to optimize the system and reduce CO_2 emissions. By means of a transport-oriented scheduling approach the demand for low-runner parts can be smoothed resulting in a more even utilization. The bundling of demand in production leads to increased utilizations, low inventory and transport costs through avoidance of transports due to bundling effects. These concepts assure a decrease in CO_2 emissions and reduced logistics costs. The starting point for the development of a transport-oriented scheduling approach was the analysis of the planning processes employed by the automotive industry.

2 ACTUAL PLANNING PROCESSES IN AUTOMOTIVE INDUSTRY

One important objective in the automotive industry is to assure the building of cars with low lead and supply times, low stock and high flexibility [11]. Regarding inbound logistics, the primary objectives are to guarantee low supply times or low waiting times in the dispatch area, in order to minimize costs. Due to these circumstances and other requirements, processes in the automotive industry are very complex. Considering the relation between the scheduling and the disposition, which is important to optimize the supply of parts, it can be seen that the disposition takes a reactive position (Figure 2). The scheduling times all the orders on the basis of planning restrictions into a defined tact. To avoid overload in the assembly stations the production restrictions have to be considered [12].

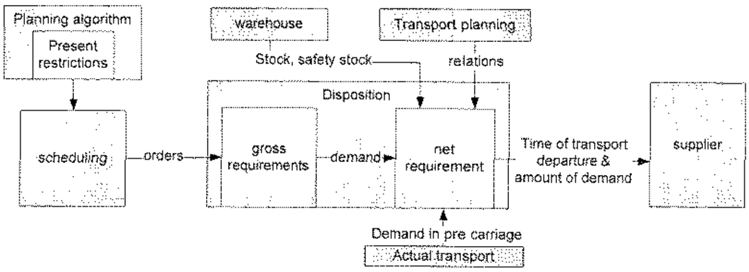

Figure 2: Linkage between scheduling and disposition.

With this and other logistical information disposition determines time and amount of demand for materials from the suppliers [11].

2.1 Processes of scheduling

Before the scheduling can be performed, orders have to be scheduled into the right time slots. Therefore, the orders are constantly scattered over a volume of a week and provisions for delivery times and production relevant restrictions are made. In a second step, the orders of a whole week are scheduled into the right sequence [13]. OEM use different algorithms to sequence the orders. Beside mixed-model sequencing, car sequencing or level scheduling are forms of applying orders to a tact. These models assure a consideration of different lead times of orders as a result of different variants to avoid overloads in the assembly stations [12]. After the planning process the sequenced orders are transferred to disposition.

2.2 Processes of disposition

The task of the disposition is to assign the demand of the production to the available transport capacities, which were planned in the transport planning process. Because of safety stocks, stocks in the warehouse and other stocks, the disposition has to appoint the right time and amount of demand to get it delivered in time (Figure 3) [11].

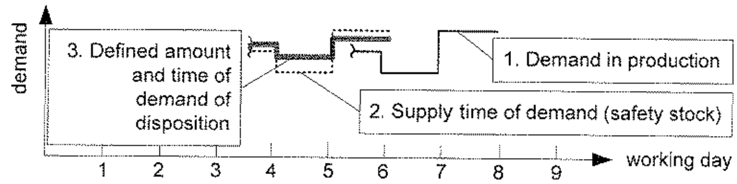

Figure 3: Determination of amount and time of demand.

To determine the right amount, disposition aligns the gross demanded requirements of a viewed period of sequence planning with the actual stock in warehouse and demand in pre carriage. The gross requirements are derived from manufacturing resources planning (MRP), where orders have been broken down according to the part list [11]. Thereupon the resulting net requirements are rounded up to the capacity of the transport equipments. In case of a FTL or a milk-run the demand is rounded up a second time to achieve high utilizations. If a LTL is used the demand won't be rounded up a second time.

To determine the right time of material delivery, disposition has to run a backwards scheduling. Initial point is the first use of materials in production. Besides the transport duration the disposition has to consider the safety stock or "safety days". A further parameter is the type of transport concept. While a LTL is being scheduled independently from a certain planned day, a FTL or milk-run has to be scheduled on defined dates, which were set by the transport planning.

2.3 Inefficiencies in actual planning processes

Because of the reactive character of disposition, the inbound logistics is operating on an inefficient level. Low utilizations or unbalanced part arrivals can be identified. Beside higher logistics costs this also causes unnecessary CO_2 emissions. Especially OEMs, which often are located in urban areas and therefore have limited space for production, have to plan the arrivals of supplier transports very accurately.

To smooth the incoming traffic volume or bundle transports, the part requirements have to be shifted in the scheduling. The starting point for an optimization is to link the sequence planning with disposition. Hence, a new concept has to be developed, where sequence planning is expanded by logistical parameters starting at the disposition and transport planning.

3 CONCEPT OF TRANSPORT-ORIENTED SCHEDULING FOR REDUCTION OF INBOUND LOGISTIC TRAFFIC

The inbound logistic objectives mentioned in chapter 2 interact. Their work dependencies are illustrated in figure 4. Objectives in the second quadrant are called active components, since they have a strong impact on the system and are weakly influenced by the system. These objectives have the highest positive leverage effect on the others [14].

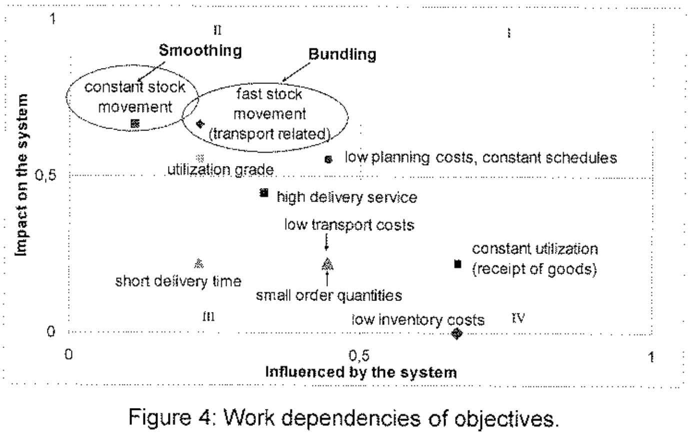

Figure 4: Work dependencies of objectives.

For inbound logistic purposes the main focus is to realize:

- **Smoothing of demand**

  Smoothing means realizing a steady demand of parts. The resulting constant stock movement and flow of parts provide a basis for a steady transport schedule [15].

  In consideration of mass customization, a constant demand exists only for parts with a high installation rate as can be seen in figure 5. Regularly these parts are high frequently sourced from nearly located supplier parks or with lean JIT transports [16].

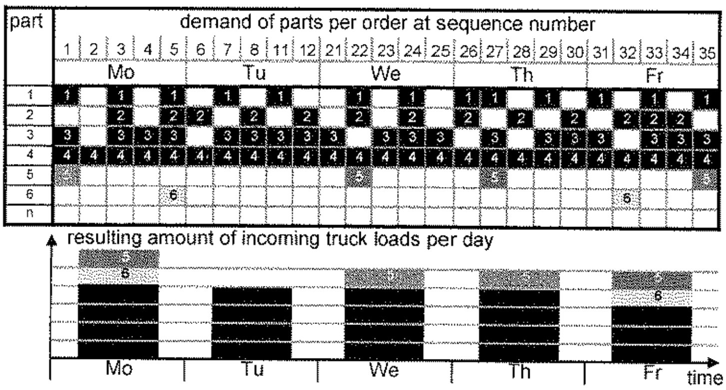

Figure 5: Sequence related demand of parts and transportation capacities.

- **Bundling of demand**

  Bundling means concentrating demand of certain parts into a shorter time span. Bundling parts of the same transport relation allows high order quantities, high utilization and low inventory costs.

  Parts with a low installation rate like part 5 and 6 are characterized by sporadic demand. Lean management consequently leads to numerous and unsteady transports. The delivery of the resulting low order quantities are carried out by low-loaded FTLs or expensive LTLs [17]. A solution is given by realizing a fast stock movement of defined transport-related parts as can exemplarily be seen in figure 6.

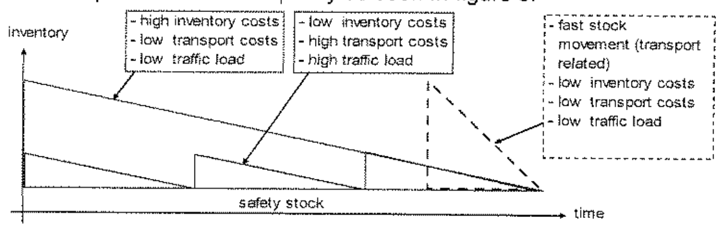

Figure 6: Low inventory, transport costs and traffic load through bundling.

Realizing bundling comprises:

- selection of the supplier and parts

- determination of the bundling time period
- determination of the bundling amount per part

Defining these requirements is part of the transport planning tasks. Besides the current production restrictions, the transport oriented specifications have to be considered in the scheduling process as it is shown in figure 7.

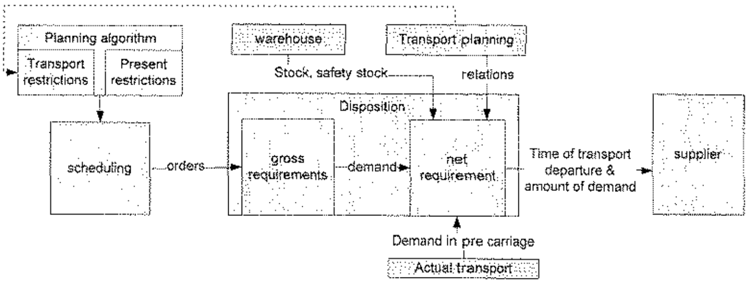

Figure 7: *Integrated process of transport and scheduling.*

Considering the transport restrictions at the scheduling, changes the sequence as it can be seen in figure 8. Through the transfer of order-number 1 for 29, 22 for 31 as well as 5 for 33, the bundling-time-period of part 5 could be reduced from 35 to 9 tacts. The demand period for part 6 is reduced from 27 to 2 tacts. As a consequence of the accelerated stock movement and high order quantities, the amount of truck deliveries for part 5 and 6 decreases from 6 to 2 deliveries per week.

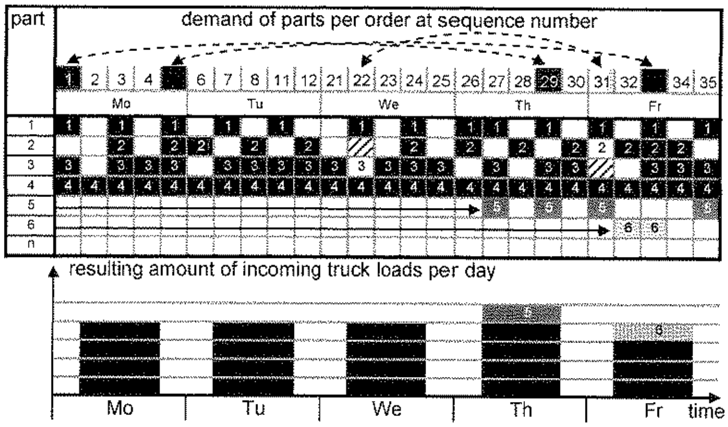

Figure 8: Bundled sequence concerning to part 5 and 6.

Gaining these advantages means accepting a changed demand of other parts like 2 and 3. The hatched boxes shows the temporal differences of demand. Change of orders is accepted as long as the present restrictions allow it. Reflecting the objectives of inbound logistic, only the most relevant parts and transport relations should be considered. Relevant factors are:

- long distances between source and sink. The longer the distance the higher is the saving potential of transport costs and pollutant emissions.
- The amount of different types of parts. The smaller the amount of different types of parts the smaller is the amount of transport-/ part related restrictions
- High inventory costs. The higher the inventory costs the higher is the present transport frequency and therefore the saving potential of transport costs and emmissions.

An evaluation of the feasibility considering transport-related restrictions was made. The results, basing on authentic data and a car-sequencing algorithm of a German car manufacturer are introduced in the following chapter.

4 EVALUATION OF TRANSPORT-ORIENTED SCHEDULING

A production plant which produces two different models on two separated lines was chosen for the evaluation. The production volume of model A amounts to 3000 and model B to 1300 cars per week. The considered time horizon amounts 5 weeks. As can be seen in table 1, 7 suppliers were selected with the following characteristics:

- long distance (300 miles on average)
- small amount of different types of parts (2-3)
- high purchase prices

The suppliers were classified in a rank of relevance for the objectives of inbound logistic. Subsequently transport restrictions were defined. According to their rank, the transport restrictions were considered sequentially in the scheduling. The amount of transport restrictions were gradually increased, until they came into conflict with one of the present restrictions. The consequences of the implementation are presented in the table below.

Supplier	Rank	Distance [miles]	Amount of different parts per supplier	Average chargeable weight [m³/week]	Average delivery per week (present restrictions)	Average delivery per week (present+transport restrictions)	Change [%]
Supplier 1	1	320	2	36,35	3,80	1,80	-52,63
Supplier 2	2	300	2	23,45	2,60	1,60	-38,46
Supplier 3	3	350	3	13,67	3,20	2,20	-31,25
Supplier 4	4	270	2	18,89	1,80	0,80	-55,56
Supplier 5	5	370	2	24,53	4,60	3,60	-21,74
Supplier 6	6	200	3	30,16	3,60	2,60	-27,78
Supplier 7	7	330	2	32,34	2,80	1,80	-35,71

Table 1: Selected suppliers and consequences of transport-oriented scheduling.

As can be seen, noticeable reductions of the transport frequency could be achieved for the selected suppliers. The total sum of transport-deliveries, pictured in figure 9, could be reduced by 2.5-3.0%, depending on the amount and priority of the present restrictions.

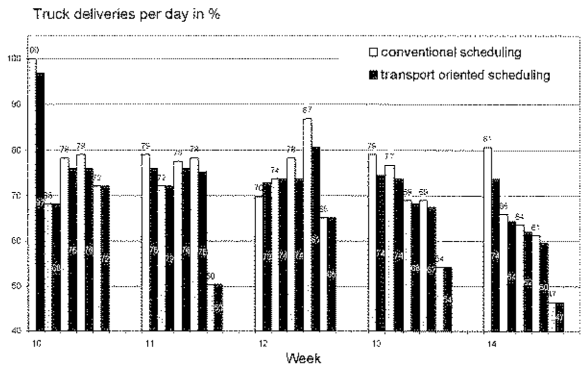

Figure 9: Linkage between scheduling and disposition.

The reduction of the delivery frequence causes a decrease of the pollutant emissions. The mentioned effects basically depend on the transport utilization of the pre and main carriage. A quantitative evaluation was not proceeded because of missing data.

5 SUMMARY

Considering transport-related restrictions like bundling at the scheduling-planning is possible. Due to the amount and priority of the present restrictions, the possibilities to expand the transport restrictions are limited. The evaluation with a time horizon of 5 weeks shows that the reduction of the total sum of transport is limited to 3.0% maximum. Nevertheless the transport oriented scheduling allows the reduction of costs and emissions for a limited selection of the most polluting and expensive relations and parts.

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