VELOS – A TRAFFIC SIMULATION TOOL AT THE INTERFACE OF INTERNAL AND EXTERNAL LOGISTICS

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ABSTRACT

Strategic planning and operational decisions affect the efficiency of the business of a forwarding agency. The traffic-logistics simulating-tool "VeloS" enables the testing of interactions and effects of various strategies. The simulation environment permits the detailed reproduction of internal and external material and information flows in logistics knots of road haulage and therefore is one of the first simulation tools for the purposes of forwarding agencies.

PROBLEMS IN THE FORWARDING BUSINESS

Forwarding Agencies

Forwarding agencies dealing with LTL (less than truckload) offer transportation services for piece goods, which include the collecting of the advised consignments at the consignor and the transport of the shipments in appropriate time and quality to the indicated consignee. Piece goods thereby is understood as "packed or unpacked goods with a weight up to approximately three tonnes, that in the case of transport-, handling- and warehousing-processes can be treated as one handling unit" (Klaus and Krieger 2004). Shipments in LTL are very heterogeneous - pallets, boxes, cardboards and non-packed items of all kinds, e.g. bar material, are transported.
The various piece goods are in general handled as groupage freight by the shippers. I. e. the transport of several, normally small consignments, which are first collected by smaller trucks in the nearer region of the collecting carrier at different consignors (forerun), then consolidated and transported by line haul as collective consignment to another forwarder, and finally distributed to the consignees by the receipt carrier.
In order to provide these transports, the shipments collected at local traffic routes in one region first have to be sorted at a terminal for the specific long-distant relations. Due to divergent mass flows in long-distance traffic semi-trailer or motor vehicles with trailers are used, the local traffic is usually done with solo vehicles.
To assure an area-wide transport network, short transportation times (night jump) and cost-efficient handling of the shipments, especially medium-sized companies use cooperation to interlink several LTL terminals by line-hauls.

Processes In LTL Terminals

After the announcement of a shipment by the consignor, the consignments are collected in the forerun during the day on various vehicles within the local traffic range and – generally during the late afternoon – transported to the LTL terminal. When a truck arrives at the terminal, mostly a registration at the porter is required. The doorman assigns a free door to the vehicle or sends it onto a waiting place.
The allocation of the vehicles to doors normally is done according to the FIFO principle (first-in-first-out), however different strategies are also possible in the yard management. (The chosen strategies thereby not only affect the yard transports, but also the internal processes).
After the docking process of the truck, the shipments are unloaded to an unloading buffer (buffer which serves only for temporary storage of unloaded consignments) by the freight carrier or the personnel of the terminal (depending on the used strategies). During this process, an alignment of the physical consignments with the specifications on the loading papers takes place. Additionally, the shipments are labelled with barcodes where required. (The usage of identification systems enables thereby not only the documentation of the transfer of risk and a continuous information flow during the whole transport, but also the routing of shipments in the LTL terminal and the network as well as the provision of additional services for the customer e.g. tracking and tracing). After completed unloading the short-haul truck leaves the yard area.
In the course of the process, the discharged consignments are removed from the unloading buffer by elevating trucks (usually motorized) or fork lifts. If a further treatment of the consignments at a handling station, e.g. in the form of quality checks or packing, is not required, the consignments are normally brought to the loading buffer for a specific route (the information can be found on the attached barcode or delivery notes). Partly, the goods are transported to universal buffer areas, but a relation-specific one enables the systematic

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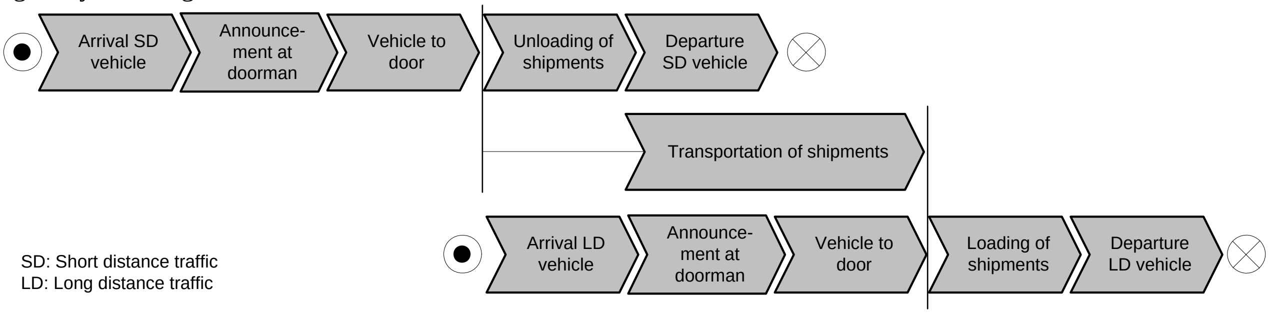
pre-assembling for dispatching and thus a faster loading of the long-distance vehicles.
The drivers of long haul trucks register as well first at the doorman and afterwards the vehicle is driven to the assigned loading dock. In order to minimize the internal material flows, a loading dock near the relation-specific buffer is allocated. The loading process in general is done via terminal staff and the consignment is identified again by scanning the barcode.

The long-distance vehicle leaves the yard and drives overnight to another terminal, which is near the locations of the consignees of the transported shipments. These processes are called outbound groupage freight. The process chain is shown in figure 1.



Figures 1: Process chain for outbound groupage freight

The process for inbound groupage freight is almost the same. The long-haul trucks arrive at the LTL terminal in the early morning. After the registration at the doorman, the consignments are unloaded at the assigned door of the terminal and transported to the buffer areas for the different short-haul traffic routes. After the loading dock allocation, the short distance vehicles are loaded with their corresponding shipments and deliver them during the morning to the consignees.
Relating to an individual LTL terminal, the processes of local collection of shipments, outbound and inbound groupage, and local delivery of shipments take place in four temporal shafts (approx. 12 a.m. – 6 p.m., 8 p.m. – 12 p.m., 1 a.m. – 6 a.m., 6 a.m. – 9 a.m.) (see figure 2) (Lublow 1995).

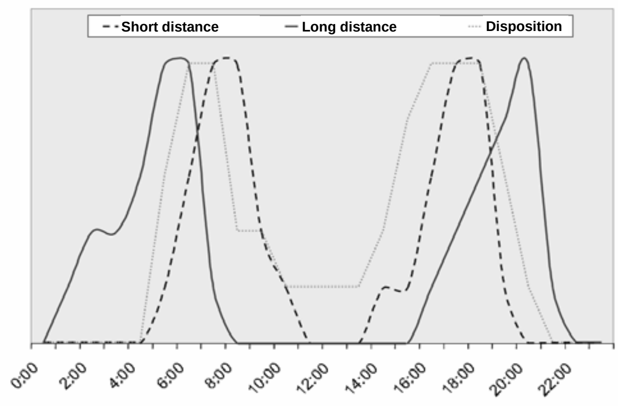


Figure 2: Utilization of resources and areas intraday

Problems Of LTL Forwarding Agencies

The forwarding business in Germany is strongly fragmented. Even large enterprises have only one-digit market shares, while the majority of the enterprises are SME (small and medium-sized enterprises). For some years, the LTL forwarding business is characterized by a strong pressure of competition; this is due to the rendered standardized services as well as the low market entry barriers and leads to small profit margins of 1-3 % (Zinn and Pielenhofer 2001). The provided services can be divided into “transport processes” and “handling processes in the terminal”. The investment and operating cost in the terminal, accounting for approx. 35 % of total costs of a LTL terminal, are determined by the layout and the arrangement decisions of the operating forwarding agency.
Layout decisions determine e.g. the path length between doors with strong relations and therefore have also an effect on handling and personal costs. So far, these decisions are made manually or based on the experience of the dispatcher, which are feasible and yield to the demanded performance (throughput). Systematic optimization of both strategic planning and operational processes rarely takes place. For this reason a large potential to reduce costs can be assumed.
The economic sector of LTL forwarding agencies in Germany is growing annually by approx. 7 %. Many terminals therefore reach their capacity limits in the course of time. LTL forwarders are in most cases SME. Due to low capital assets, therefore they first try to avoid the accruing problems by changes of dispatching (e.g. double usage of doors) in daily business. However, in the long-term questions about an expansion of the terminal respectively an analytic ascertaining of handling options in dispatching are raised. Often thereby strong restrictions have to be considered, for instance given areas or the directive, that daily business may be as little disturbed by changes as possible.

Pieced goods shipments are in most cases heterogeneous, hence the application ranges of mechanized sorting and unloading technologies is reduced and the handling personnel and cost-intensive (DHL 2005). A "good" dispatching and/or planning of resources therefore has large effects on the costs of a terminal, because an optimization of the terminal by the change of technology is often not possible.
Problems which occur in day-to-day business, e.g. delayed vehicles or daily fluctuations in volume, are remedied merely by using adequate operational strategies, for instance by modified strategies in the yard management.

THE TRAFFIC LOGISTICS SIMULATION ENVIRONMENT VELOS

The chair of traffic systems and logistics, University of Dortmund, has recently developed a traffic logistics simulation environment (VeloS – Verkehrslogistische Simulationsumgebung) in order to test the interaction and the effects of strategic planning (layout decisions, structure of network) on operational procedures and to derive rules for internal and external logistics processes.
VeloS, based on the simulation software Enterprise Dynamics, permits the illustration and simulation of material and information flows in logistics knots (e.g. terminals, distribution centres) of road haulage.
The modelling of logistics knots is done on a microscopic scale by using several atoms, which enables to simulate each individual consignment and thereby the connected internal and external processes such as vehicle movements and transports with forklifts.
The simulation-borders of the system are at the doorman of the terminal, therefore all processes on the yard area of a forwarding agency are modelled.
For VeloS, some preconfigured logistical atoms could be used (e.g. conveyor belts, cranes, forklifts), but in addition, forwarding specific atoms had to be designed, layout-specific ones as well as strategic ones, for instance logic atoms for routing the vehicles at the yard. Some of the developed atoms are explained in the following paragraph.

Layout-specific Atoms

For the modelling of a terminal of a forwarding agency, internal as well as external layout atoms had to be implemented. Based on the processing of vehicles, which is not limited to traffic infrastructure, new area atoms were needed: Holding areas for vehicles both at the doorman and in the yard, shunting areas for coupling and detaching of trailers respectively for pick up and set down of swap bodies and containers and areas at the loading points of the terminals, where not only loading and unloading, but also switching processes of shunting can be executed.
Concerning the internal areas, paths for forklifts, different buffers (loading, unloading, general), docks, ramps and processing and storage locations are modelled.

Fleet

In the model different vehicle types and transport containers are applied for the fulfilment of internal and external transport requirements, e.g. solo vehicles, vehicles with trailers and semi-trailers. In addition a railway siding is realized, so transport containers can be delivered and picked up by wagons. The term “transport container” comprises fixed superstructure, swap bodies and containers, which can be used both in road and railway traffic.
While fixed superstructures are connected to a vehicle durably and thus clearly assigned, swap bodies are without reference to a vehicle and hence realized as autonomous units. Swap bodies can be transported on various vehicles and vehicle types, if the particular vehicle has an undercarriage construction.
Depending on the superstructure of each vehicle and the loading status of each transport container (loaded, empty), for each vehicle several superstructure-container-combinations are permissible, altogether 36 types. In the model, an alteration of combinations is implemented.

Strategy Atom – Yard Management

Individual strategy atoms were developed for modelling the process of routing of vehicles on the yard area. Although the model distinguishes only between three areas at the yard (waiting area, shunting area, loading area), the routing of vehicles is extraordinarily complex due to the complex fleet, the divergent orders (loading/ unloading) and the various permissible combinations concerning superstructure and transport containers:
At the shunting areas the various vehicle combinations are separated or combined. In addition they are buffers for trailers, swap bodies or containers, which can be moved internally by transfer cars or reach stackers. At the shunting area a vehicle with trailer and swap bodies e.g. it can detach its trailer, set down the swap bodies of the trailer and the vehicle and leave the yard without trailer depending on its driving order. If the driving order allots the pick up of new swap bodies, several transport chains are possible as well.
At the loading areas route-referred consignments are handled additionally to the functions described above for the shunting area. This applies both to the motorized vehicles and to swap bodies or semi-trailers. Some vehicles can only be loaded/unloaded at specific loading areas, e.g. for side or yard discharge. Each loading area is equipped with a door and a dock leveller for balancing different heights of loading edges.
A complex yard management atom is used for controlling the traffic on the yard of a forwarding agency, with which the individual units of the fleet are conducted to the correct place of destination. The atom conducts a list of permissible transport chains

depending on the situation of the vehicles entering and leaving the yard as well as the states of all external areas and administers the destinations of each transport containers. This basis supports the doorman with the assignment of vehicles to loading areas or a solo vehicle with coupling the correct trailer at the shunting area.

Strategy Atom – Buffer Areas

Even within the forwarding agency, strategy atoms are used, e.g. for administration of buffer areas. In particular the clever utilization of areas is a substantial factor of success for forwarding agencies due to the high percentage of manual activities, especially in transportation and sorting of consignments. For implementing the strategies concerning the usage of buffer areas, VeloS considers internal areas in a grid 10 cm x 10 cm. This modelling permits the calculation of the actually used areas with consideration of the different sizes of the consignments (euro pallets, industrial pallets, half pallets, boxes, parcels and bar material).
The administration of buffer areas is controlled by external algorithms, which determine the position of each shipment as well as the time required for the retrieval. The algorithms doesn't aim at a mathematically optimum allocation of the area (e.g. algorithms for strip-packing), but at the representation of proceedings close-to-reality.
For that purpose, not only the dimensions of the area and the consignments have to be considered, but also the orientation of the shipments on the fork lift and therefore the storage direction, the accessibility of the pallets as well as reloading if necessary. The last-mentioned have to be considered in particular at the transportation of a specific pallet from the buffer to the vehicle (depending on the chosen internal strategy it is possible that first all consignments for a relation have to be collected at the various buffers and prepared bundled, even if this results in internal restoring on the individual buffers).

USAGE OF VELOS

By using the simulation tool VeloS it is possible to test the effects of long term and operational strategies in a simultaneous model, particularly since optimum strategic layout decisions and optimum operational dispatching strategies and their interaction crucially affect performance (e.g. throughput for each time unit) as well as costs (investment, operation).

Layout Planning

The term layout planning means strategic decisions, which have to be made within the scope of new building or expansion of LTL terminals respectively. This comprises the determination of shape and size of the terminal, the number of docks and their arrangement at the wall. Additionally, the function of the gates (short-distance traffic, long-distance-traffic or mixed) have to be determined as well as which relation is assigned to which gate.
Moreover, questions concerning size and spatial arrangement of internal areas (for buffering and pre-assembling of unloaded shipments) as well as the position of travel paths have to be answered in the process of layout planning. Concerning the yard area around the terminals, decisions concerning number and arrangement of waiting areas, parking areas for transport containers and shunting areas as well as the flow of traffic (one-way or cross traffic) have to be made (Clausen and Goerke 2004).
In addition, the decisions of layout planning determine the building and the capital outlays and have huge impact on the in-plant handling costs. As an example, if the docks for long-distance-traffic with strong traffic volumes are too near to each other, the fork lifts used for unloading might obstruct each other and operational personal and handling costs will rise.

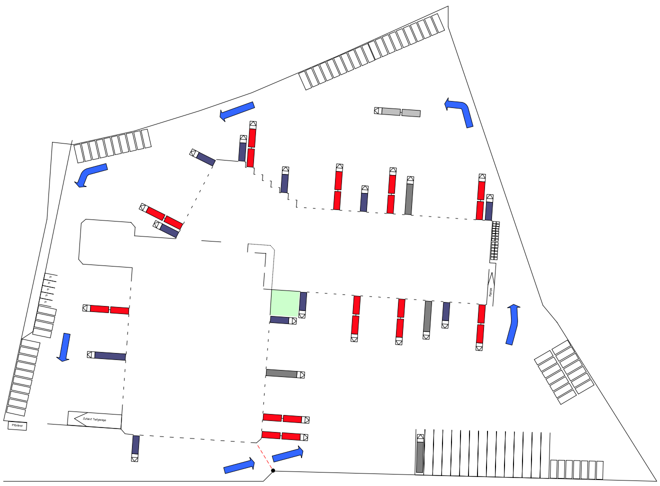


Figure 3: Layout of a LTL forwarding agency

Decisions In Dispatching

Operational decisions in a forwarding agency affect the operation processes in the terminal and the usage of involved resources (fork lifts, workers). Examples for decisions in dispatching are the prioritization of waiting vehicles at the assignment to free docks or the prioritization of loading and unloading of vehicles at the gate and therefore the allocation of handling equipment and human resources. Another decision determines whether unloaded shipments are first buffered at logistics areas or if they are loaded directly into available vehicles. Besides, decisions adress number and kind of resources involved (conveying equipment, staff) as well as their temporal distribution (shift schedule) and responsibilities (firm allocation of personnel to certain areas, certain activities or similar) to make. Altogether there is an abundance of criteria and factors, which affect the decisions of dispatching.
The decisions of dispatching concerning the operational processes and their specification depend partially on the

made layout decisions (e.g. number of buffer areas). On the other hand, operational decisions also have impacts on the strategic layout planning. If the unloaded shipments should be loaded immediately into the available vehicles, less area for buffering and pre-assembling of pallets are needed. This can lead to terminals with fewer handling space or the unloading area can be narrower.

Application

The simulation tool VeloS was used for the first time for modelling a LTL terminal of a medium-sized forwarding agency in North-Rhine-Westfalia with 87 docks, 80 long-distance routes, 450 vehicles with 3,900 shipments per day and 43 forklifts.

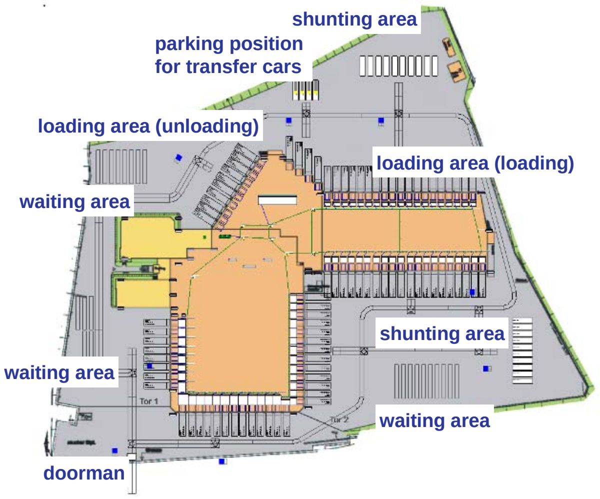


Figure 4: Model of a LTL forwarding agency

The model is used for optimizing the decisions in dispatching and identifying bottlenecks, e.g. on the road network as well as on the usage of docks for unloading. By analysing the throughput it is possible to determine the maximum performance in the LTL terminal based on different operating strategies.

Flows and composition of shipments and vehicles in the model are generated by using a complex data generator, which enables the detailed modelling of the system load for either forwarding agencies or distribution centers based on statistic distributions and real data.

OUTLOOK AND CONCLUSION

The traffic-logistic simulation environment VeloS offers support both for the strategic and the operational range. By using the model atoms, forwarding agencies can be modelled in detail and their typical flows of shipments and vehicles can be generated.

The model allows evaluating the traffic composition for each vehicle type, the utilization as well as the operating time of resources and, as result, the fill rate of the terminal based on the number of accomplished driving orders and waiting time. By peak performance rating (e.g. minimal resources for given throughput and layout, maximal throughput for given resources), weak points can be identified and action options derived.

In addition, VeloS offers the possibility to compare new scientific methods, latest findings and models (e.g. algorithms for yard management, dynamic route planning, control strategies based on data concerning the actual situation on the road) with the realistic processes in a logistics knot. As example, a tool developed at the chair of transportation systems and logistics deals with the yard management, which optimizes the optimum allocation from vehicles to doors for a given layout with consideration of various basis conditions - based on mathematical or heuristic techniques (Chmielewski and Clausen 2005).

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AUTHOR BIOGRAPHIES

LARISSA NEUMANN was born in Moers, Germany, and went to the University of Dortmund, where she studied logistics and obtained her degree in 2004. She works at the chair of transportation and logistics at the University of Dortmund as scientific assistant, where she does reseach in the fields of commercial traffic and simulation in traffic and transport logistics.