Cross-docking Concept – Role, Advantages and Disadvantages

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Market needs and demands are contingent upon continuous work on finding better, faster, more efficient and more economic systems of goods flow. The intention is to optimize the logistic processes along the supply chain in terms of achieving economic, temporal, spatial and environmental improvements. One of the possible methods to improve the efficiency of supply chains is the introduction of the cross-docking (CD) concept. The essence of the CD concept is reflected in the consolidation of goods flows into the CD terminals with little or no storage of goods. The objective is to achieve optimization of time, space and costs. This paper presents the role of the CD concept in logistics chains, description of the CD terminals, and then the advantages and disadvantages of their application. The primary objective of this paper is to present the role, advantages and disadvantages of implementing the CD concept in logistics chains.

Key Words: cross-docking, concept, terminals, advantages, disadvantages

1. INTRODUCTION

The organization of goods flow through supply chains is contingent upon the market needs. Market needs and demands are complexified by the development of advanced techniques and technologies, which automatically requires that the movement of goods flows from source to destination be optimized to the greatest extent possible. The coordinators of goods movement undertake daily to seek new methods, techniques, concepts and strategies with a view to optimizing the goods movement system in supply chain.

The Cross-Docking (CD) concept was developed in the eighties of the last century. This concept emphasizes the transformation of goods at the CD terminals. The CD terminals represent nodes where goods flows are consolidated for final delivery. The CD concept aims to increase the efficiency of goods delivery along the supply chain.

The fundamental principles of the CD concept are reflected in the consolidation of goods flows at CD terminals with little or no storage of goods. The objective is to achieve optimization of time, space and costs. The wide range of fields of implementation of the CD concept has enabled its use in various production and distribution sectors, including printing (magazines and newspapers), supply of spare parts, postal and urban distribution systems, intermodal transport (IT) and food distribution [1].

The topic of this paper is the CD concept, its role, as well as the advantages and disadvantages of its implementation. The principal contribution and the objective of the paper is to present the role of the CD concept in a systematic manner in logistics chains, focusing on advantages and disadvantages.

The paper, in addition to the introduction, consists of four more sections. The following section provides the literature overview. It is followed by a section where the CD concept is described and basic CD models and their characteristics are presented. The next section deals with the CD terminals, and this is followed by a section which presents the advantages
and disadvantages of the CD concept. The last section is devoted to concluding considerations, summarized work results and directions for future research.

2. LITERATURE REVIEW

The CD concept appeared as early as the 1980s [2] when it was implemented in the supply chains for Wal-Mart. Although the CD concept began to be implemented in the 1980s [3], it did not attract greater attention for further research until later.

The CD concept and the CD terminals may be defined differently. The MHIA (The Material Handling Industry of America) defines CD as the process of accepting inbound goods and preparing them for further dispatch, without placing the goods in a storage area [4]. The fundamental idea behind the CD is the transfer of inbound consignments to outbound vehicles without storage [3]. CD is the central point in the supply chain where goods are unloaded from inbound vehicles, sorted and then loaded onto outbound vehicles [5]. CD is a common practice used by companies to reduce storage and transport costs associated with consignments of different goods from multiple suppliers to multiple destinations [6]. Therefore, CD is a concept which achieves its purpose through the consolidation of goods in the CD terminal in such a manner that all inbound goods are dispatched to end users after being consolidated, and all of this is done without or with very little retention of goods, i.e., storage.

CD terminals are used for the reception of products from suppliers or manufacturers for several different destinations and consolidate them with goods from other suppliers for a collective final delivery [7].

Various problems concerning CD terminals have been dealt with in the literature so far. Li et al. [8] investigated models for arranging internal operations in the CD terminals with the aim of reducing storage costs and penalties for early or late delivery. Napolitano [9] investigated the different types of operations associated with CD terminals (production, distribution, transportation, retail) and the impact of each of them on the system’s efficiency.

Yu et al. [10] studied a CD terminal where a conveyor belt performs the product transfer. The authors have defined several models for the scheduling of goods for outbound vehicles and the arrival system for the vehicles at loading points. Fliedner et al. [11] defined a CD with the possibility of temporary storage on a vehicle (trailer). Boysen [12] dealt with the analysis of CD terminals and the effect of vehicle scheduling on the system without the application of storage. The three parameters were observed and minimized: overall flow period, the loading period of outbound vehicles and the period for processing and delays. The group of authors dealt with the design of CD terminals and the definition of models which may improve the overall efficiency of logistics and distribution networks [13]. Fatthi et al. [14] studied the rationalization of CD through the allocation of trucks to the loading docks. Having dealt with vehicle scheduling in CD terminals, Arkat et al. [15] proposed a mathematical model for the scheduling of inbound and outbound vehicles in CD terminals with multiple loading decks. Wisittipanich et al. [16] presented a mathematical programming model for the allocation of loading decks and truck sequences in multi-deck systems with the aim of minimizing the total operating time. Rohrer [17] indicated that simulation helps to ensure success in CD systems by determining optimal hardware configuration and software control, as well as by identifying failure strategies before problems occur. Montreuil introduced a new paradigm, Physical Internet (PI), which defines smart CD terminals [18].

3. CROSS-DOCKING CONCEPT

The CD concept emphasizes the transformation of goods flows at CD terminals as special nodes in logistics networks. Previous experience with the CD concept points to numerous advantages achieved by its implementation in the supply chain, but also to disadvantages which need to be studied and eliminated. The CD concept is used by many companies dealing with LTL (Less Than Truck Load) and LCL (Less Than Container Load) consignments. The objective is to achieve multiple optimizations, which primarily refer to the consolidation of goods flows, the delivery periods for goods, as well as the reduction of costs. Observing from a broader perspective, the CD concept operates with the support of numerous additional tools and strategies, beginning with consolidation, the Just In Time (JIT) strategy, satellite tracking, bar codes and software support [1].

While observing the flows of goods through supply chains without implementation of the CD concept, the two most expensive operations which emerge are the storage of goods and consolidation following the storage period [3]. The CD concept minimizes or entirely eliminates these operations. This concept requires a high degree of coordination between the collaborators in the supply chain.

The investigation of the convenience of implementing the CD concept for different types of consignments leads to the conclusion that CD is more functional and expedient when the consignments are established, that is, when the requirements are less variable [19]. On the other hand, CD will not function if there is a large imbalance between production and
demand [13]. The imbalance between production and demand requires the storage of goods. Storage cannot be avoided if the production capacity is larger than the market demand.

Nevertheless, if there is a reverse case of market unsaturation with products, it is necessary to observe the JIT strategy and implement direct delivery. In these cases, the CD concept cannot be implemented. The implementation of the CD concept necessitates the synchronization of partnership, trust, communication between the collaborators in the supply chain, control, personnel, equipment, devices and tactical management [20].

During the implementation of the CD concept, first and foremost the consignor and the consignee of the goods must be certain that the implementation of this concept will not yield negative effects in the form of delivery delays, lost consignments, or the unavailability of goods at the proper time and in the proper place but, on the contrary, that the concept itself will facilitate the distribution of goods from the supplier and the final delivery to the customer. Therefore, when implementing the CD in certain supply chains, a test period is suggested in order to gain confidence in the system itself and its functionality [20].

CD is unable to function without quality electronic data exchange in the supply chain. This concept is based on real-time operations, the objective of which is to reduce and eliminate inventory retention, and any information delay slows down the system and it loses its purpose.

Once the goods are in the system, the data about them must be known at every moment (whether there is a temporary hold, in which position it is placed if the goods are scheduled for temporary storage and waiting for any reason, etc.), which is achieved by implementing the Warehouse Management System (WMS). WMS plays an essential role in the successful implementation of CD [21], [10].

There are two models of the CD concept: sorting according to products and sorting according to the final destination of the goods [7]. When discussing sorting by products, we refer to the cases where consignors send one type of goods to multiple destinations. These goods are then consolidated at the CD terminal for final destinations.

The simplest situation to clarify this model is the case of a Full Truck Load (FTL) consignment of the same product to a CD terminal. The same products in the CD terminal, which arrived in one loading unit, are scheduled for several outgoing vehicles, which will make deliveries to end users, consolidated with other goods for the same destination (Figure 1).

Sorting according to the final destination is based on the principle that consignors send different types of products in one consignment, which will then be consolidated in the CD terminal to form final loading units for the goods dispatching [7] (Figure 2).

With the CD concept, in most cases, the consignor is already familiar with the consignee, and information is obtained about the further flow of the goods by reading the bar codes on the goods, which significantly accelerates the goods processing time in the CD terminal. The presented CD models are simple if we disregard numerous impacts (daily workload, changes in vehicle arrival and departure times, etc.) to which the entire supply chain is susceptible and which largely affect the functionality of the CD concept.

4. CROSS – DOCKING TERMINALS

The initial forms of CD terminals were affiliated with rail transport in the periods when massive quantities of wagonloads were delivered to railway storages, where goods were consolidated and dispatched to end users by road transport [7]. The same principle was exploited for the transshipment of goods in maritime transport, from large ships to smaller ships and barges [7]. The intention was to achieve a consolidated delivery to the final recipient.

CD terminal is a transshipment terminal, i.e., a transfer point between inbound and outbound flows, without long-term retention and storage of goods. The role of CD terminal is the consolidation of goods flows from different consignors and their dispatching to the
end user. CD terminals also serve, if necessary, as temporary storage for goods. Nevertheless, this represents an operational decision at the terminal level, which will depend on the schedule of outbound vehicles and their availability, the urgency of delivery and the very characteristics of the goods. In any case, temporary storage should be avoided when unnecessary, on the one hand due to congestion at the terminal and on the other due to the acceleration of time-based operations of consolidation of goods flows, aiming at their timely further dispatch.

The characteristics of the CD terminals are defined by means of transport, primary functions, size, geographical location, load type, node accessibility, operational technologies, and operations [22]. There are physical, operational and characteristics of flows [3]. The physical characteristics refer to the layout of CD terminals in terms of the form of the space itself and the spatial plan. The form of the CD terminals may be derived as I, L, U, T, H and E [3]. The form and size of terminals determine the number and arrangement of doors for inbound and outbound vehicles.

Handling of goods inside the terminals is organized depending on the further flow of goods (whether there is temporary storage or direct loading from the inbound to the outbound vehicle) and on the shape and size of the goods’ packaging. Goods can be handled by pallet forklifts, hand pallet jacks or manually without the use of equipment and devices [3]. Operational characteristics refer to the organization of operations within the CD terminal, which is determined by the requirements of inbound and outbound vehicles for the consolidation process. The organization of the operation of a CD terminal can be based on the principle that there are precisely defined spots for inbound and outbound vehicles without changing them in the process of transshipment of goods, while the movement of goods is performed crosswise within the terminal [3]. There is also a mixed method of organization [3] where inbound and outbound vehicles may access any dock, without strictly defined accesses for the entry and exit of goods, i.e., vehicles, and thus greater congestion is created in the terminal itself, which requires better organization so that all tasks within the terminal are completed in a timely manner. Should the “priority loading” strategy be used, then the vehicle may be moved before completing the entire transshipment, where another vehicle takes its spot in order to complete the loading/unloading process on it. Then the moved vehicle is subject to interruption during the operations and must wait for its completion due to the urgency or priority of completing the process on another vehicle [3]. Regarding the flow characteristics, the pattern of arrival of vehicles at the terminal is certainly considered. The concept of organizing the arrival of vehicles is predominantly arranged in the following manner. The vehicles from the same geographical area are dispatched in the same time period and arrive at the terminal in the evening hours. The consolidation of goods flows is done during the night, which are then dispatched in the morning for delivery to the destination. Goods coming from a greater distance arrive at the terminal in the morning and they are consolidated and dispatched during the day [3]. The departure time of the vehicle may also create certain limitations in the operation of the CD terminal, which pertain to the logistics of the carrier and the further planning of the vehicle schedule following the executed delivery or dispatching from the CD terminal. With such time constraints, it happens that the terminal must release a vehicle which is time-bound for the next transport, and that a part of the goods which arrive later must temporarily be stored until the arrival of the next vehicle which can pick it up. Also, regarding the inbound vehicles, the retention period at the terminal may result in having vehicles fully unloaded and released as soon as possible, without waiting for all outbound vehicles in order to consolidate directly from inbound to outbound vehicles. CD terminals also encounter cases where the modification of goods is permitted. Most of the goods arrive at the terminal so that their destination is known in advance and direct consolidation is sought there. However, there are cases when it is important that the same quantity of goods is dispatched from the terminal, but it does not have to be goods which immediately enter the terminal, but rather goods which have previously arrived, been stored and which generally necessitate additional operations, such as marking and labeling of goods. In this case, the temporary storage of the goods and one stage of their processing (marking) are inevitably included [3].

Smart CD terminals, which operate based on the physical internet, have emerged as an upgrade to the existing CD terminals, with the purpose of multiple optimizations: system automation, reduction of retention of goods in the system, lower CO₂ emissions, less engagement of human resources, reduction of night driving and driving on long distances. Therefore, smart CD terminals represent an economic, temporal, spatial and social improvement of classic CD terminals. The concept of smart CDs (S-CDs) was introduced as an initiative aimed at improving supply chains by introducing modern technologies using the digital internet [23]. Logistics systems have reached an economic, environmental and social peak [24], [25]. In order to achieve the sustainability of logistics systems, a new paradigm of PI (physical internet) was defined [24]. The notion of the PI paradigm arose as an aspiration to change the classical methods in which physical objects are moved, stored, acquired and used,
into a method which will function and be connected as computers are connected via the internet [26]. The primary objective of introducing the PI paradigm is the reorganization of the existing method of supply in an economically, environmentally and socially acceptable method.

5. ADVANTAGES AND DISADVANTAGES OF THE CROSS-DOCKING CONCEPT

The CD concept will not succeed if the advantages and disadvantages of its implementation are not compensated and realistically balanced.

CD is only a link between the consignor and the consignee, and if its implementation fails to produce positive effects for the generators of certain flows, then CD fails to have its purpose either.

Some of the most important advantages of implementing the CD concept imply economic, temporal, spatial and environmental improvements. Reduction of storage and inventory retention costs and implementation of incidental consolidation not only yield economic advantages, but also reduce the space required for stock-keeping and the number of freight vehicles required to serve the final distribution of products. By reducing the number of vehicles and their better routing, environmental effects are achieved in the form of a reduction in CO₂ emissions, a reduction in traffic congestion and at the goods reception points, as well as a reduction in transport costs. The reduction of the complete elimination of the storage of goods leads to production according to realistic market requirements conditioned by timely ordering [18]. Smaller quantities of inventory generate less trapped capital and therefore a better use of resources. The implementation of information technologies within the CD concept provides for a timely exchange of information along the supply chain, which leads to a lower risk of loss or damage to goods. The status and position of the goods is known at every moment [23]. Timely production, which conditions the flows of hauled goods, enables precise insight into market requirements, and thus better control of product distribution [18]. The consolidated deliveries of goods, in addition to the mentioned positive effects, also help to achieve time improvements in the form of a reduction in the time required to track the movement of individual consignments, the stock-keeping period in storage areas, as well as the time of delivery of goods. Implementation of the CD concept increases the frequency of delivery with FTL consignments and decreases the number of LCL deliveries. The S-CD terminals provide additional advantages compared to classic CD terminals. Ladier et al. [27] state that the use of S-CD terminals compared to classic terminals results in a 45% reduction in the completion time of operations and a 26% reduction in the distance traveled by employees, while the level of stocks is reduced by 12%. The fill rate of transport units increases by 70-75.5%, while the CO₂ emissions decrease by 58% [28].

The disadvantages of implementation of the CD concept can be divided into internal and external. Internal disadvantages refer to the parameters of the system itself (investments, appropriate software support, system sizing) and represent the parameters which may be more easily predicted and managed. The CD systems require large initial investments [18]. An adequate level of information support is needed from the very beginning of the implementation of the CD concept, as well as a timely exchange of information between all stakeholders in the supply chain. This system requires great trust and responsibility in partner relations. For the system to be functional, it is necessary to achieve precise coordination between all participants [29]. External disadvantages are much more difficult to manage and eliminate, so a timely exchange of information among all stakeholders is necessary to eliminate the external disadvantages. A fast and reliable transport system is necessary to support the CD terminal. Numerous disruptions in the schedule of reception and dispatching of vehicles to and from the terminal are caused by external impacts on transportation systems which cannot be predicted or can only be predicted for shorter time intervals. One of the disadvantages of the CD concept is the impossibility of receiving a large quantity of goods unexpectedly. This occurs due to the imbalance of production and demand in combination with the low storage capacity of the consignor. For the CD concept to achieve its purpose with as few unexpected and unforeseen circumstances as possible, which may affect the efficiency of the entire system, a high level of planning and work organization is necessary. One of the biggest disadvantages which may occur when implementing the CD concept is the lack of strong strategic and tactical leadership that manages the operation of the terminal [29].

6. CONCLUSION

This paper analyzed the role of the CD concept and how it operates with the use of CD terminals and smart CD terminals. The paper systematically presents the advantages and disadvantages of the implementation of the CD concept, thus achieving the objective and contribution of the paper. The implementation of the CD concept primarily yields economic, temporal, spatial and environmental improvements. A detailed consideration of the advantages and disadvantages of the implementation allows one to gain knowledge...
about the benefits that such systems bring, but also about the impacts which may lead to the inefficiency or non-functionality of the implementation of the CD concept. It is essential in every individual case, according to realistic indicators, to analyze possible disadvantages that may affect the very outcome of the implementation of the CD concept. Future research may be headed in the direction of researching methods to reduce negative external factors that affect the efficiency of the CD concept.

REFERENCES


CROSS DOCKING KONCEPT - ULOGA, PREDNOSTI I NEDOSTACI

Potrebe i zahtevi tržišta uslovljavaju konstantan rad na iznalaženju boljih, bržih, efikasnijih i ekonomičnijih sistema protoka robe. Namera je optimizacija logističkih procesa duž lanca snabdevanja u smislu postizanja ekonomskih, vremenskih, prostornih i ekoloških poboljšanja. Jedan od mogućih načina unapređenja efikasnosti lanaca snabdevanja je uvođenje Cross-Docking (CD) koncepta. Suština CD koncepta se svodi na konsolidaciju robnih tokova u CD terminalima sa malo ili nimalo skladištenja robe. Cilj je postići optimizaciju vremena, prostora i troškova. U ovom radu je prikazana uloga CD koncepta u logističkim lancima, opisani su CD terminali, a potom prikazane prednosti i nedostaci njihove primene. Osnovni cilj rada je prikazati ulogu, prednosti i nedostatke primene CD koncepta u logističkim lancima.

Ključne reči: cross-docking, koncept, terminali, prednosti, nedostaci