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A Proposal to Improve the Transport System of Household Appliances by Means of Road Transport

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Abstract

The purpose of the paper was to present a method to improve the transport system in the transport of household appliances by means of road transport. Based on the example of the BDE (Back Door Extension) system, the process of loading and placing household appliances in trucks was simulated by use of the FlexSim simulation program and objects appropriately matched in it. 3D model and the "ProcessFlow" block diagram, divided into four stages, were used for this purpose. A comparative analysis of the number of loaded appliances was carried out by use of the MEGA semi-trailer with and without the BDE system. On their basis, measurements of efficiency of production points were performed, along with the times of storing goods at distribution points, and analysis of the results based

on graphs of speed and quantity of transporting products from production sites to direct loading to the semi-trailer, the dependence of the number of shipments produced at production points on the exact times and the distribution of activities performed when loading equipment into trucks by forklifts. It was found that thanks to the properties of the BDE system, shown on the example of refrigerators and other tested appliances, the MEGA semi-trailer can hold up to 43% more articles. In addition, the appropriate planning of production or warehouse space with the use of objects available in the FlexSim program, which reflect the appliances used in reality – can help to properly assess the degree of suitability of a given system, a technological idea for planning production with matching objects.

Keywords: Transport System, Shipment Transport, Methods of Shipment Identification, Back Door Extension System

1. Introduction

When reviewing literature studies in the field of transport systems, the concept of a system should be defined. The concept of a system comes from the Greek word σύστημα systema, meaning a complex thing. There are many definitions and concepts related to it, so it is difficult to clearly determine its purpose:

"A system is considered a set of elements, subsystems, which, by characterizing mutual features and properties between themselves, constitute one common whole.",

"A system is an organized object that operates in a specific environment and consists of smaller elements - subsystems. Subsystems are systems within a larger system that are connected by many relations based on cooperation, thanks to which each achieves the main goal and contributes to the success of the whole.",

"An open system is a system that interacts with the environment. The vast majority of companies or enterprises are open systems. It is a system composed of several subsystems, including: Production, organizational, economic, decision-making, work and information" ^[1].

When considering a transport system in relation to transport, all of the above should be taken into account. concepts and definitions of the system used in road cargo transport. According to J. Gluch, the transport system is perceived as "a set of details, connections and processes by which we define cargo and passengers as a demand for transport services and constitute the output of the system" ^[2].

2. Factors influencing the transport of cargo by road

The basic criterion for fulfilling the transport of cargo by road is its efficient course from the place of dispatch to the place of receipt in due time, in the condition of the transported goods and within the costs of the transport order agreed between the carrier and the forwarder, strictly observing the procedures related to carrying out such orders [3].

The dictionary of logistics terminology defines "cargo is a resource in the form of raw material, material, product, manufactured product, etc. used for movement from the

supplier to the recipient in the supply chain" [4]. In addition, cargo is characterized by a variety of features resulting from its transportability. The following play an important role in the transport of cargo by road:

- Carriers,
- Forwarders,
- Contractor service employees,
- Warehouse managers or representatives of manufacturing companies cooperating with transport companies (Table 1).

Table 1: Factors influencing the transport of cargo by road, including the division of labor and the cooperation of all departments involved in the transport process

Carrier	Forwarder	Department customer service	Companies production and storage
Appropriate taking care about the vehicle during its operation	Acceptance orders and putting them on the transport exchange	Contact with representatives manufacturing or warehousing companies regarding details related to the load (type, loading method, adapted trailer, order cost, etc.)	Preparing the load (packaging, labeling, creating loading units)
Safe driving during executing the transport route	transport documents (CMR, TIR carnet)	Preparation of commercial documents together with confirmation of establishing transport cooperation	Preparing the room for reception cargo, min. acceptance, storage, completion, issue goods
Convoing together with transport	Constant contact with the carrier or dispatcher to inform about any delays related to delivery cargo on time	Contracts of mandate (confirmation of performance orders)	Activities related with the arrangement of the load in the vehicle along with its appropriate securing
Setting vehicle at the loading and unloading place	Notification orders together With settlement of the work performed	Making Connections permanent cooperation With companies production and storage	Delivery confirmation goods on time and inform the transport company about it

Source: Prepared on the basis of [5]

3. The process of transporting cargo using transport systems

The transport process is a series of activities aimed at delivering cargo from the sender to the recipient in a given place and time in the most efficient way possible [3]. We can divide this series of operations into several groups, i.e. administrative and forwarding activities, activities related to movement, organizational and preparatory activities and executive activities.

The process of transporting cargo using transport systems can be divided into several stages, taking into account all factors and disruptions that affect its course.

The stages of carrying out the transport order process for cargo transport are most often carried out in the following way:

- The forwarder receives guidelines and details regarding a given order from the customer service department,
- Placing them on the transport exchange and dividing them between the company's drivers,
- Providing the customer with general information regarding the details of the order in accordance with the customer's expectations, establishing with him the freight for the carrier in such a way that it is lower than the cost of the entire order, obtaining the highest possible profit,
- After reaching an agreement, a transport plan is developed, which consists of including information including, among others: About selecting the right trailer, the method of loading the equipment (e.g. BDE system), guidelines or legal regulations regarding the transport of dangerous, oversized, perishable goods, etc. and specifying the payment deadline for the service performed [5],

- Acceptance by both parties of the conditions for carrying out the transport order, which must include all the rights and obligations of the principal towards the contractor and vice versa, as well as the so-called "catches" securing in the event of one of the parties failing to meet the terms of the contract.

However, before the freight forwarder reaches an agreement with the customer and the carrier regarding the details of the order, they must also take into account the type of truck adapted to the weight of the load, the adapted semi-trailer or many other technical details, such as the type of bodywork, the method of transporting the load using at least two different modes of transport, e.g. intermodal transport on a given section of the route, the maximum load capacity of the vehicle and, from the IT side, the possibility of the driver's current presence using tools that streamline the process of reporting road accidents, traffic jams on specific sections of the road or if the driver went in the wrong direction, then the freight forwarder/dispatcher could immediately inform the driver in order to indicate a possible error or remedy further action in the event of unexpected and stressful situations that would delay the time of arrival at the unloading site. During the execution of the transport route, the carrier must be in constant contact with his "guardian" in the cases mentioned above, but they should also synchronize with each other in the event of reporting the equipment and its completion for customs clearance, road tolls and ordering reloading, storage or its inspection.

During the final transport process, i.e. unloading the goods to the recipient, the ordering party verifies the compliance of the load with its description in the bill of lading, prepares a protocol confirming the compliance of the goods with the

order, its quantity, weight, etc. and at the very end settles the amount due to the company transporting the equipment.

4. BDE system description

The first of the recently introduced solutions supporting more efficient and effective arrangement of household appliances (e.g. washing machines, refrigerators, dishwashers, gas cookers, etc.) is the BDE system (Back Door Extension). It was patented by the president of EPO-Trans Logistic S.A. based in Tychy - Piotr Ozimek in 2005. It consists in opening the rear doors in such a way as to be able to extend the semi-trailer by 25-40 mm on each side (from the left and right) in order to be able to load more equipment in the truck. This system uses semi-trailer tractors with MEGA semi-trailers, which are able to fill the entire width of the cargo box. It reduces the risk of damage related to the arrangement of goods and overloading the cargo box.

MEGA trailers are equipped with the XL certificate, which allows the transport of household goods without the use of frame boards, providing more space for loading.

MEGA trailers have a safety net constructed of steel cables running along and across the tarpaulin. It is used especially when transporting household appliances, where the safety boards are removed. Household goods are packed in cardboard packaging and are most often cuboid or cube-shaped with equal dimensions and a stable base, standing evenly. Fastening means such as belts or fastening ropes are not used, due to the household appliances being filled from wall to wall and from side to side, which could further damage the individual packages together with the equipment. The width of the MEGA trailer's cargo box is 2.5 m. After extending the rear portal, the box is from 2.55 to 2.58 m^[6].

The BDE system is not very complicated in practice and execution, but you must remember to follow a specific order of execution, in which it is carried out in several stages:

- Removing the steel cable and clamps from the left and right sides of the semi-trailer,
- Releasing the tarpaulin tension using a crank,
- Pulling the profiles out of the mechanism sockets and spreading the tarpaulin,
- Opening the rear doors and securing them with locks on both sides,
- Releasing the cross straps to stiffen the cargo box and lifting the roof of the semi-trailer using the corner post mechanism using a crank,
- Dismantling the frame protection boards from the sides of the semi-trailer,
- Unfolding the stanchions by extending the support and disconnecting the stanchion, usually 3-4 times over the entire semi-trailer on both sides,
- Sliding the tarpaulin and attaching them to the extended stanchions.

Thanks to the BDE system, it was calculated that during the process of loading household appliances into the semi-trailer, 28% more equipment can be accommodated, which significantly increases the efficiency of the vehicle loading process, and consequently also of the transport process^[7].

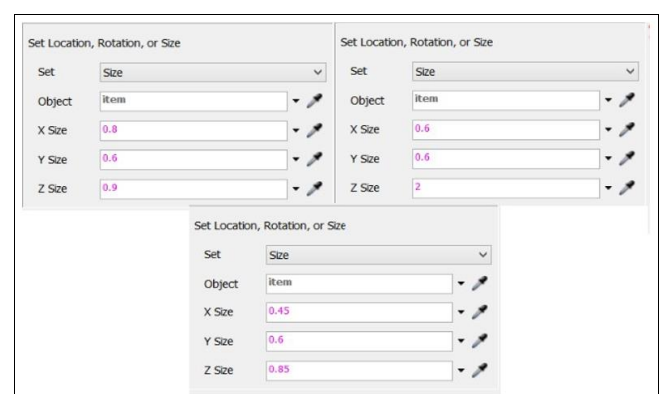
5. BDE system improvement model

Based on the BDE system mentioned and described in the previous subsection, a model of the process of loading

household appliances (using refrigerators, washing machines and dishwashers as examples) was created in the FlexSim simulation program. The simulation model presenting the method of arranging household appliances takes into account the ideally assumed dimensions of both the three devices mentioned and the MEGA semi-trailer used for this operation, additionally increasing its surface area. The proposed proposal to improve the process of loading household appliances into the semi-trailer allows for greater efficiency and effectiveness of the planned and organized transport process. The presented three-dimensional (3D) model consists of 29 objects: Three production points as "Source" type objects, three belt conveyors "Curved Conveyor", three warehouse racks as "Standard Rack", three distribution points as "Queue" objects, three forklifts "Transporter", three objects connecting trucks with distribution points - also "Queue", nine points indicating places where a truck should be when entering the production company called "NetworkNode", one "Queue" object called Waiting room as a place for the truck to stop during the driver's visit to the dispatch point and one "TrafficControl" synchronized with the "Input Control" point used to stop vehicles in order to carry out the inspection process verifying the correctness of the driver, vehicle or type of load. Additionally, connections (Connect Objects) were created between individual objects in such a way as to enable the greatest possible realization of the process of the truck driver reaching the loading site and the arrangement of household appliances in the vehicle.

6. How to make the model?

At the beginning of its creation, three objects of the "Source" type were used as three production points from which household appliances were created, assigning a different type of product to each of them. Then, they made a route from the place of their creation to the distribution points or warehouse shelves (in case the limit of equipment located in the distribution sections was exhausted) using belt conveyors. The "Source" objects were programmed in such a way that a different type of household appliance flowed through each of them. Figure 1 shows their assumed dimensions.



Source: Own study based on FlexSim program

Fig 1: Assumed dimensions of household appliances in "Source" type objects

The model includes 3 household appliances: Refrigerators, washing machines and dishwashers with the following dimensions:

- **washing machine:** Depth (X-axis) 0.8 m, width (Y-axis) 0.6 m, height (Z-axis) 0.9 m,
- **refrigerator:** Depth (X-axis) 0.6 m, width (Y-axis) 0.6 m, height (Z-axis) 2 m,
- **dishwasher:** Depth (X-axis) 0.45 m, width (Y-axis) 0.6 m, height (Z-axis) 0.85 m.

The access path through the “Triggers” option was used, indicating the differentiation of the production of household appliances at “Source” production points in terms of their “Set Size”.

In addition to the main model with 3D objects, a block diagram was designed "ProcessFlow", divided into four stages of carrying out the transport process from the moment the truck driver arrives until the semi-trailer is filled with cargo and the driver leaves the company's base.

In the first stage of the process, when the carrier entered the company's yard, he had to undergo an entry control lasting 10 seconds. If all the details regarding the driver, vehicle registration or loading location were correct, the driver went to the waiting room, where, getting out of the vehicle, he had to go to the dispatch point. At this point, he learned about the selection of the transshipment dock and the type of household appliance cargo to be loaded.

When the process of creating and reaching the distribution points and storage racks of household appliances took place, the process of entering the trucks to the yard of the warehouse and production company, determining the details regarding the type of transported goods together with the place of selecting the transshipment dock took place. After this part, the driver would drive to the appropriate dock, where the loader would transport the equipment from the distribution points to the vehicle with the semi-trailer.

The next stage involves the forklift operator loading the truck. Depending on the type of household appliances being transported, the driver would drive dishwashers to the first loading dock (Loading dock 1), refrigerators to the second (Loading dock 2), and washing machines to the third (Loading dock 3). The truck operator is assigned a distribution point for goods depending on its type, so for example, if he has to load refrigerators (second storage rack, second production point), he is assigned a second distribution point. This is due to the reduced risk of mechanical damage related to improper positioning of equipment both at distribution points and in trucks.

After filling the entire trailer with household appliances, the driver drove out of the assigned loading bay, going to the exit control point (exit gate), and finally setting off from the company yard, thus starting the transport route to the unloading site.

7. Solution Improvement Forecast

After developing the BDE (Back Door Extension) system model, measurements and graphs were made that mostly concerned the process of loading household appliances, focusing on the efficiency of distribution points, the number of items produced by production points, whether forklifts are able to fill the entire trailer, taking into account their dimensions and the trailers, and how much more household appliances can be loaded by the forklifts in the MEGA trailer and how much in the MEGA trailer, additionally

using the BDE system. The measures of the measurements carried out on the basis of the model are production points, distribution points, forklifts and household appliances in combination with trucks.

At the beginning of the results analysis stage, tests were carried out on the efficiency of production points responsible for creating ready-made household appliances for distribution and loading. Table 2 presents the maximum efficiency of the production part, taking into account the number of load units created and the time of the entire transport process from the moment of manufacturing household appliances to the moment of their complete loading into the trailers.

Table 2: Performance points production

Name object	Efficiency [number created charge unit/time process]
Point production washing machine	640
Point production dishwasher	1045
Point production refrigerator	569

Source: Prepared on the basis of FlexSim program

Analyzing the above results, it can be stated that the more similar the dimensions of the goods, the more of them can be produced and placed in warehouse racks and distribution points, which undoubtedly has an impact on the course of the preparation process for loading. In the example of dishwashers, where the efficiency value of the production point is the highest, it results primarily from the smallest overall dimensions and the possibility of faster preparation for storage and distribution through a shorter route from the production site to the racks and distribution sections. In the case of refrigerators, the main factor of the smallest result is its height dimension, which does not allow for their production and faster distribution in points together with the load of a larger quantity to the semitrailer.

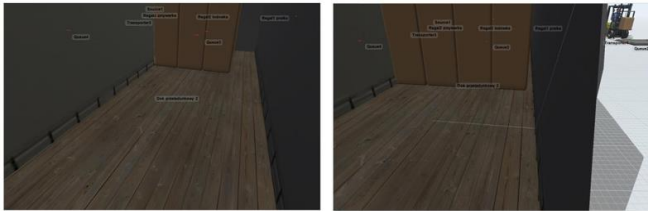
One of the most important studies improving the BDE system solution is the comparison of the arrangement of household appliances together with counting their exact number in trucks with semitrailers of the following types: MEGA without the BDE system and MEGA connected to this system. Table 3 presents the adopted dimensions of the semitrailers according to the actual dimensions.

Table 3: The dimensions of semi-trailers adopted for trucks in the model

Dimensions [m]	Type semi-trailers	
	MEGA without BDE system	MEGA With BDE system
Width	2.48	2.55
Length	13.6	13.6
Height	2.94	3

Source: Own work

The entire model was simulated, comparing the amount of loaded household appliances in the MEGA trailer and also the MEGA, but extended with the BDE properties. Figure 2 shows the interior of the trailer along with its gradual filling of household appliances, using refrigerators as an example.



Source: Prepared on the basis of FlexSim program

Fig 2: Comparison of the methods of arranging household appliances in trucks using refrigerators as an example: On the left in a semi-trailer without the BDE system, on the right with the BDE system

The number of refrigerators that fit in the semi-trailer from its width, where without the BDE system three refrigerators can fit, and with this system – four. When the forklift operator filled the entire semi-trailer with refrigerators, 42 refrigerators were placed in the MEGA semi-trailer without BDE, and 60 in the MEGA semi-trailer thanks to the BDE system, which is even about 43% more equipment than without BDE (Fig 7).

The next stage was to examine the speed of the flow of household appliances from production sites through distribution points to trucks, depending on the duration of the process. It was the distribution points that were the measure of this stage of the study.

As the process nears its end (by 9:00), the flow rate reaches its peak and if the forklifts do not perform the operation of moving loads to the semi-trailer, they stop working, which results in a decrease in the flow of new goods for distribution. From 9:00 a.m. 9:30 we can observe a complete lack of new cargo flow, due to the distribution points and warehouse racks being filled to the brim.

It is worth noting a similar trend to the example, where at 9:00 the peak point is reached, in this case the largest number of loads that the production sections are able to produce. The points responsible for the production of refrigerators and washing machines are no longer able to produce an even larger batch of devices from 9:00 and at an increasingly later time they reach a decrease in production capacity. The production point of dishwashers is able to create slightly more batches, because by 11:00 it reaches its peak capacity, where it is not possible to produce even more equipment later. This results from the fact that when the loading process ends, the production points create items only for storage, whether in shelves or directly in the points, and then the equipment used to store the products is already completely filled.

The work of forklift operators assigned to specific distribution points was also analyzed. The results were generated from the moment the first forklift loaded the first truck until the last truck was loaded. When comparing the work of forklifts, it is important to note the division of activities into 3 stages: Travel with a load (marked in green), travel without a load (red), idle (blue). The truck responsible for transporting washing machines achieved the highest result (slightly over 92%) of its use during the entire transport process, evenly distributing the percentage of travel with and without a load, and thanks to this, the lowest idle result was achieved. Activities were evenly distributed for forklifts transporting dishwashers and refrigerators. An important factor turned out to be the fact that during the simulation the first truck was at the loading dock for

transporting washing machines and the forklift started work the earliest.

8. Summary

Based on the conducted research on the presentation and comparison of the method of arranging household appliances using the BDE system (Back Door Extension, or a system for expanding the rear doors) using the FlexSim simulation program, the following conclusions should be drawn:

- Thanks to the properties of the BDE system, presented on the example of refrigerators and other tested devices, up to 43% more items can fit in the MEGA trailer.
- The times of storing household appliances in distribution points depend on their dimensions, efficiency in the process of loading them into trucks, the amount of manufactured equipment created and the random order in which drivers drive to the loading docks.
- The results of the efficiency of production points are correlated with the method of setting up the points used for storing and storing products, the route to them and the transport efficiency of trucks in order to load and transport them to the unloading site. Another key factor is the uninterrupted operation of production points and continuity in the process of loading goods.
- After the analysis of the simulation process presenting the course of loading household appliances using the BDE system and based on the measurement results - it should be stated that when there is a stop related to a temporary decrease in the inflow of drivers waiting to load goods, then the efficiency of both production sites and the entire vehicle loading process decreases.
- Appropriate planning of production or storage areas using objects available in the FlexSim program, mapping the devices used in reality - can help to correctly assess the degree of usefulness of a given system, a technological idea for production planning with appropriately matched objects.
- FlexSim software can therefore serve as a supporting tool for future technological solutions for production, storage and efficient loading and unloading processes.

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