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ASSESSMENT OF TECHNOLOGICAL AND ORGANISATIONAL IMPROVEMENTS IN THE LOGISTIC DISTRIBUTION HUB USING DISCRETE EVENT SIMULATION

Abstract

Purpose: The viability of companies in today's turbulent and dynamic market depends on their ability to change and develop together with the market. Primarily under the influence of technological innovations and new customer demands, the logistics sector is under great pressure of change. The focus of this paper is on the functioning of the distribution hub as an important node in the distribution network and the operational processes it implements. The aim of the paper is to investigate different variants of the development of logistics processes in the distribution hub and thus help decision-makers in deciding on the level and performance of potential technological improvement.

Methodology: The research was conducted in a real distribution hub using a simulation approach. In particular, discrete event simulation (DES) was used, which allows supporting the dynamics of logistics processes, examining the impact of random variables on processes and determining process performance in different scenarios. Two models were formed in the paper: the As-Is model that imitates the existing processes in the distribution hub, and the To-Be model that assumes a higher technological level of the process.

Results: Findings from this paper have two practical implementations. The first one is to use As-Is models as an insight into the current situation in the distribution hub. The second implementation is to use a To-Be model as a decision support system for evaluating different solutions in the execution of logistics processes.

Conclusion: The obtained research results provide an opportunity to examine different ways of the functioning of processes in the distribution hub before making changes in the real system, which is especially important for managers of such systems.

Keywords: Distribution hub, discrete event simulations, logistics processes

1. Introduction

Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third-party logistics services providers (CSCMP, 2013). By managing the flow of goods, logistics supports and connects the functioning of various economic sectors and is one of the key factors in the development of both individual companies and national economies. At the core of these different material flows (raw materials, products, shipments, waste, etc.) are the material handling processes (loading/unloading, transhipment, transfer, packaging, labeling, formation/dismantling of cargo units, sorting, commissioning, etc.), storage and transportation, as well as that efficient logistics is of fundamental importance for the functioning of various economic sectors. In the 21st century, primarily under the influence of technological development and changed customer requirements, there is no sector in any industry that has remained untouched by major changes and challenges in business. The ambient turbulence has created a need for dynamic business processes and companies are looking for models that can evolve and adapt efficiently business processes to the changing conditions and the changing business strategies (Clempner, 2014). Different company goals, which reflect different market conditions (economic, political, social) and business priorities (capital return, customer satisfaction, employee satisfaction, company growth, cost reduction, etc.) are reflected in the structure of logistics systems and processes. In such conditions, logistics is under constant pressure of changes and faces many dilemmas aimed at improving the operational efficiency and sustainable business of companies.

The focus of this paper is on one segment of logistics, i.e. on the functioning of the distribution hub as an important node in the distribution network. Hubs are special facilities that serve as switching, transhipment and sorting points in many-to-many distribution systems (Alumur & Kara, 2008) so that intensive operational processes take place in them, which are an integral part of the functioning of the distribution system. In this paper, through a case study in the postal center as a distribution hub that exists within the postal logistics network of the Republic of Serbia, different variants of the unfolding of logistics processes are investigated in order to increase their productivity and overcome operational difficulties. Discrete event simulation (DES) was used in the research, which makes it possible to support the dynamics of logistics processes, examine the impact of randomly changing variables on processes and determine process performance in different scenarios. Two models were formed in the paper: the As-Is model that imitates the existing processes in the distribution hub, and the To-Be model that assumes a higher technological level of the process.

The remainder of this paper is organized as follows: Section 2 describes the research background and research approach. Section 3 describes the case study and the structure of the developed simulation models, and discusses the obtained results. Finally, concluding remarks are given in Section 4.

2. Background

2.1 Logistics processes in postal logistics center

The key characteristics of postal services are reflected in a massive user demand for the transfer of postal items, which is realized through postal processes that generate physical moving of mails to the recipient. From an organizational point of view, for the implementation of postal services that demand the market (national operators are conditioned to provide a universal service), it is necessary to establish a uniform postal network (on the national and international level), and use unique technologies and standardization of equipment. The structure of the postal network and its equipment is conditioned by the economic capabilities of operators, traffic volume, and in the case of a national operator, government investment policies. In recent decades, postal operators are faced with the challenges of rapid technological development, market liberalization, segmentation and increasing competition. In such conditions, the industry has evolved to include traditional post (like package and mail delivery), courier services, freight services and e-services (Chan et al., 2006) in logistics fright flows. Accordingly, leading European postal operators (such as Deutsche Post DHL, La Poste and Royal Mail) have expanded their operations in the logistics sector. In support of these transformations is the fact that domestic letter traffic in Europe (28 countries) between 2013 and 2021 fell by about 38 percent and in the same period domestic parcel volumes increased by 122 percent (23 countries) (Publications Office of the European Union, 2022). The majority of mail in the universal postal services are letters with standard dimensions (about 70%). The decline of these services will be greater in the years to come, due to the development of electronic services. Today, electronic services are already being used that allow citizens to pay all the bills and taxes via their mobile phones, and the recent surge in e-commerce and world trade has led the parcel delivery industry to be one of the fastest growing industries (Kulkarni et al., 2021). These trends can help the Post of Serbia public enterprise plan and innovate its business. Today, competition leads companies to improve their functionality or durability of innovation and survival (Liu et al., 2020).

Postal centers represent an important link in the postal network and realize one stage in the delivery of items between the sender and the recipient. In line with the market-oriented and customer-driven development of postal operators, many traditional postal centers have expanded their range of services and grown into postal logistics centers (PLC). PLCs are located in the traffic hubs to achieve the concentration and diffusion of shipments to the geographical area that they cover, and from the logistics point of view, a PLC performs the functions of intralogistics (Lisec & Rihter, 2007). The incoming flows of shipments as independent quantities are the result of various external factors, while the outgoing flows can be seen as dependent quantities that reflect the functioning of the PLC. The technology and organization of the process in a PLC depends on the type and category of postal items and the processing differs accordingly: ordinary LC items of standard dimensions, AO items and non-standard LC items, registered and valuable items, packages, express items, etc. In general, the basic processes implemented in shipments in a PLC are: taking postal conclusions, classification of conclusions (dismantling) according to the type of shipment, transfer to a sorting center, sorting, formation of conclusions (consolidation of the load unit), waiting for shipment, transfer to the place of shipment, loading and shipping (issuance of formed conclusions). So, the functioning of a PLC is based on fundamental logistic processes with postal items. The processes of consignments arriving in the PLC and the dispatch processes of processed consignments occur according to a defined time schedule, and the processing processes engage the resources of the PLC (space, equipment, employees) and must be fulfilled by the defined deadlines. The number and structure of postal items that are processed daily in the PLC are variables that affect the duration of the mail processing process and, due to the defined processing deadlines, the required resources as well.

2.2 Simulation modeling of logistics processes

Modeling is a problem-solving method, in which the system under study is replaced by a simple object that describes the real system or its behavior. It is based on abstraction, simplification, quantification, and analysis. According to Sterman (2000), modeling is a part of the learning process and it is iterative, a continual process of formulating hypotheses, testing, and revision, of both formal and mental models. As an object of modeling, the system is defined as an aggregation or assemblage of objects joined in some regular interaction or interdependence toward the accomplishment of some purpose (Banks et al., 2004). The model of a system is the replica of the system, physical or mathematical, which has all the properties and functions of the system (Singh, 2009).

The logistics system is a complex socio-technical system that supports the rational flow of various material goods through the implementation of logistics processes. Two approaches can generally be used to model logistics processes: analytical and simulation (Hung et al., 2006). While analytical models provide accurate and often optimal solutions, which generally imply significant simplifications (compared to the real system) and mathematical formulations complicated to solve, simulation models can support the real characteristics of logistics processes and enable objective evaluation of performance in different functioning scenarios, which is especially important when planning new and redesigning existing processes. Simulation of the effects of redesigned processes before their implementation creates the opportunities for decision-making in relation to the planned changes. For the research in this paper, simulation models were used that respect the time dimension of the process and allow the modeling of complex processes in a logistics system such as a PLC. More precisely, from the existing approaches to simulation modeling (such as discrete-event simulation, dynamic simulations, agent-based simulations, and hybrid simulations), discrete-event simulation (DES) was used in this research for simulating operational processes in the PLC.

DES is "modeling of systems in which the state variable changes only at a discrete set of points in time" (Banks et al., 2004). The basic idea of DES is to abstract from the continuous nature of the system and consider only some "important moments", "events" in the system lifetime. DES gives an insight into the business processes of a particular system by describing the system through process maps. Process maps provide a critical assessment of what really happens inside a given company (process identification or As-Is process mapping) and they also serve for designing a new solution (To-Be process modeling). Process modeling and the evaluation of different alternative scenarios (a To-Be model) for improvement by simulation are usually the driving factors of the successful reengineering process (Trkman et al. 2007). DES is an established tool for the design and management of large-scale mail sorting and distribution systems (White et al., 2001) that allows a better understanding of the dynamic behavior of a postal system, as pieces of mail flow through from receipt to dispatch. This approach incorporates the variability and interdependence of the system and allows the analysis and understanding of both the current behavior of the system and the future as a result of numerous changes in the system (Greasley, 2003).

3. PLC case study

The case study was carried out on the example of the PLC Novi Sad (Republic of Serbia). The PLC can be considered as a post hub with the basic function of receiving, sorting, delivery and transhipment of incoming mail. In the observed PLC, different mail classes are processed (priority mail express[1], first-class mail[2] and standard mail[3] and international mail). Accordingly, during processing in the PLC, different shipments (i.e. mail classes) have a different sequence of activities through the PLC, and an average of 7,000,000 pieces of mail are processed in the PLC in one month. The focus of the research is on the quantification of the temporal characteristics of operational processes in order to analyze the engagement of employees and find opportunities to increase their productivity in order to eliminate difficulties in the PLC functioning.

3.1 Data collection

Based on the process approach and a hierarchical structure of the process, all activities and resources (employees and equipment) engaged in mail processing processes in the PLC were identified. For the observed problem, the number of employees and their time commitment to the identified activities and processes are crucial, which, in accordance with the postal operator's business policy, must be

1 *Priority mail express* represents service which allows fastest transfer of all kind of mail (letters, parcels, advertisements, bills, etc.). This service also provides tracking of shipments during transfer and it is available only in domestic traffic (i.e. within the boundaries of the Republic of Serbia).

2 *First-class mail* includes valuable parcels and valuable letters. By the business practice of the Post of Serbia, medium and large packages are commonly considered as valuable parcels. Valuable letters are special kinds of postal shipments that are processed in separate PLC sections, since these are confidential contracts between companies, international mail, government shipments, etc.

3 The Post of Serbia considers advertisements, circulars, newsletters, small parcels, merchandise, bills, etc. as *standard mail*. Standard postal items are classified on the basis of their dimensions, and in the practice of the Post of Serbia, there is a classification into ordinary and nonordinary mail. Ordinary mail includes letters with standard dimensions that consist of recommended letters and priority mail. Recommended letters are similar shipments as post mail express. They also allow tracking of letters and but are slower than post mail express shipments. Priority mail is mail that has priority in terms of delivery to the final consumer.

completed within precisely specified deadlines. The number and structure of shipments, organization and work technology, and time frames for the realization of processing directly affect the number of employees. The number and structure of postal items that are processed daily is a randomly variable quantity (it depends on a number of factors and primarily on the month of the year and the week of the month), whose daily volume ranges from about 15,000 to over 800,000 items.

In order to identify and quantify the time potential of PLC employees, simulation models of existing processes (As-Is) and projected processes (To-Be) have been created. Data were used to form these models from the document "Postal Statistics" (Djakovački, 2006) on the number and structure of postal items (for the selected month) downloaded from the PLC and determined by direct monitoring of the process in the PLC and the technical parameters of the sorting machine (Toshiba, 2023).

3.2 Structure of the model

In order to understand the existing processes, there is a common practice to create a process map model of existing processes in the organization. Process maps are a graphical way to describe the process, which helps to structure the information collected during the case analysis or process improvement project (Cachon & Terwiesch, 2009). For business process modeling, an academic version of iGrafx, a software package for business process mapping and simulating, was used, which is often used by researchers who have dealt with similar problems of process modeling (Trkman et al., 2007; Maslaric et al., 2012; Mircetic et al., 2013).

The DES model consists of elements connected by links that describe the flow of processes with shipments in the PLC. The basic structural elements of the diagram are the activities that take place and enable the process to take place. Each activity is defined through the type and number of resources (technical means and personnel) and the duration of the activity (constant or stochastic). In the To-Be model, activities are either modified from the aspect of time and resources needed for their realization, or they are transformed into new activities according to the requirements of the sorting machine, or they are eliminated as redundant. The paper presents the results of two models, namely:

1. As-Is model - imitates existing processing processes with postal items;
2. To-Be model - assumes a higher technological level of the process, i.e. introducing a sorting machine, which requires significant investment in equipment and employee training.

The simulation covered the period of March 2023. The relevant output from the model is the duration of the processes (active and total).

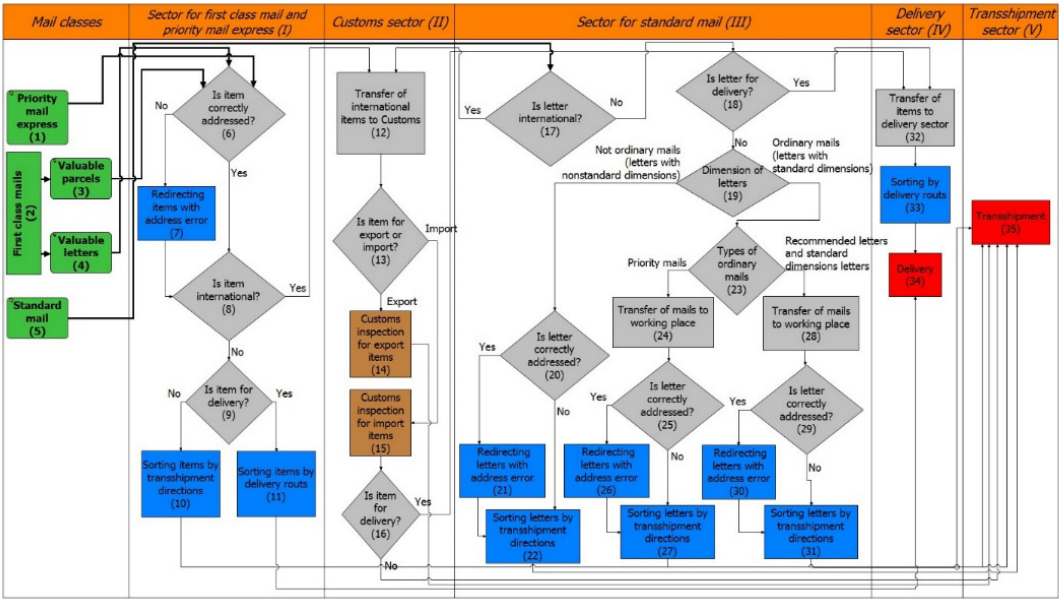
3.3 Model description and discussion of results

3.3.1 As-Is model

The process map for the As-Is model (Figure 1) presents four sectors in which incoming mail is processed according to mail type (i.e. mail class). Each mail class has different specificities and requirements for processing. Green color objects represent the generators of mail classes. The daily incoming mail distribution is highly stochastic, where the biggest picks occur at the beginning of the month.

After incoming, the mail is then directed to particular sectors according to their requirements for further processing. Grey color objects represent the activities where the duration of the activity is determined by measurement at the PLC during vocational training carried out in the PLC Novi Sad. Blue color objects represent the activities related to manual sorting of incoming mail and are based on the standard workload of the postal operator (1,000 pieces of mail per hour). Brown color objects represent the activities for which the execution time was taken from the "Postal Statistics" document (Djakovački, 2006).

Figure 1 As-Is model with manual mail sorting and processing



Source: Authors

Simulating the existing activities by means of the As-Is model, mail processing times for each PLC sector are determined and presented in Table 1. It is obvious that mail spends the most time in the standard mail sector (≈54 minutes), whose task is to sort incoming mail by dividing it into mail for delivery (to local end-users) and mail for transhipment to the other PLC. The simulation also shows that in this sector mail spent considerable time waiting for resources to be served. The reason is a lack of manual labor in this sector, as well as small operating capacity, which consequently causes mail to queue. As a result, mail spends time waiting for its turn to be processed.

Processing lead time is the time that elapses from the moment mail enters the PLC to the time when it is ready for delivery or transhipment (i.e. exit the PLC). The goal is to keep processing lead time as low as possible, so that the center could process all incoming mail without long delays[4]. In As-Is, the average overall processing time per one mail is≈57 minutes (Table 1).

Table 1 Average processing time in minutes per postal mail by the As-Is model sectors

Sector	Number of pieces of mail	Average processing time	Average working time	Average time spent waiting for processing
I	146,714	1.06	0.03	1.03
II	10,471	33.27	8.01	25.26
III	5,242,636	53.83	0.09	53.75
IV	2,276,721	15.34	0.3	15.04
Total number of pieces of mail in March 2023	7,519,357	Total number of pieces of mail for transhipment		5,242,636
Processing lead time				57.49 minutes

Source: Authors

4 Level of service defined by the Post of Serbia is that received mail should be processed within 24 hours from the moment of receipt.

Processing time through sectors is a good indicator of bottlenecks in the terminal, and the implied utilization was used to identify bottlenecks, Table 2 (column 8).

It can be seen in Table 2 that the standard mail sector has the highest implied utilization, and that other sectors have relatively small utilizations and could handle additional mail traffic. Consequently, it could be concluded that the standard mail sector represents the bottleneck of the terminal. Therefore, the maximum throughput of the entire PLC is by causality directly determined by the capacity of its weakest link, in this case, by the capacity of the standard mail sector. However, mail does not arrive evenly throughout the month. Every month there are peak load days in which the load is three times higher than the average (usually the second week of the month), when large companies deliver bills to the population (e.g. bills for electricity, cable TV, utilities, etc.), which additionally burdens PLC processes.

Table 3 shows the results of the simulation of the PLC operation on peak load days. Again, the standard mail sector has the highest processing time (it takes an average of 1,792 minutes to finish mail sorting), so the total time is also significantly higher and amounts to 1,778 minutes.

Table 2 Bottleneck identification in the As-Is model during mail processing[5]

Sector	Activities in the As-Is model	Number of workers per shift	Resource capacity[6] (pieces of mail/hour)	Resource capacity per day[7]	The average number of pieces of mail per day	Total number of pieces of mail (month)	Implied utilization[8]
I	Sorting parcels for transhipment and delivery (activities 10 and 11)	1	1,000	21,500	261.6	8,111	>1%
	Sorting letters for transhipment and delivery (activities 10 and 11)	3	3,000	64,500	4,470.1	138,574	7%
II	Sorting parcels for transhipment and delivery-import (activities 14 and 15)	1	4.6	98.8	6.2	195	6%
	Sorting parcels-export (activities 14 and 15)		9.2	197.2	4.2	131	2%
	Sorting letters for transhipment and delivery-import (activities 14 and 15)	3	20	430	196.3	6,087	46%
	Sorting letters-export (activities 14 and 15)		36	774	130.9	4,058	17%

5 Table 2 consists only of the activities that have the longest processing time in the observed sectors.

6 Capacity for sectors I, III, IV are taken from the literature, which recommends that one worker can process 1,000 pieces of mail/hour. Sector II is more specific than other sectors since there the goal is not to process mail as quickly as possible, but to control mail, following the government customs regulations. Accordingly, for sector II, capacity is determined by measuring the average time needed for mail inspection, and for activities (sorting parcels for transhipment and delivery-import), (sorting parcels-export), (sorting letters for transhipment and delivery-import), and (sorting letters-export), it takes 13, 6.5, 9, and 5 minutes, respectively. Therefore, resource capacity is determined by dividing one hour by the average time needed for the execution of activities. For example, 13 minutes are needed (activities 14 and 15) for the parcel sorting task, and capacity is determined as 60/13=4.6 parcels per hour.

7 Resource capacity for one day is obtained by multiplying the worker's capacity and the number of engaged workers (column 5) by 21.5 hours, which represents the total working time of employees with breaks, i.e. 3 shifts with half-hour breaks, and one hour lost in the preparation for work.

8 In logistics, the resource implied utilization is calculated by the following formula (Cachon & Terwiesch, 2009): implied utilization=current throughput/capacity*100%, or adjusted to our case study, implied utilization=average number of shipments per day/resource capacity per one day*100%.

Sector	Activities in the As-Is model	Number of workers per shift	Resource capacity[6] (pieces of mail/hour)	Resource capacity per day[7]	The average number of pieces of mail per day	Total number of pieces of mail (month)	Implied utilization[8]
III	Sorting nonordinary mail for transhipment and delivery (activities 22, 27 and 31)	2	2,000	43,000	24,946.9	773,354	58%
	Sorting priority mail for transhipment and delivery (activities 22, 27 and 31)	5	5,000	107,500	98,955.9	3,067,635	92%
	Sorting recommended letters and standard dimension letters for dispatch and delivery (activities 22, 27 and 31)	3	3,000	64,500	42,409.7	1,314,701	66%
IV	Sorting postal items for delivery (activity 33)	5	5,000	107,500	71,357.9	2,212,095	66%
Total number of workers per shift		23					
Total number of workers per day (three shifts)		69					

Source: Authors

Table 3 Average mail processing time in minutes through the As-Is model for peak load days

Sector	Number of pieces of mail	Average processing time	Average working time	Average time spent waiting for processing
I	11,416	1.09	0.03	1.06
II	393	33.95	7.96	25.99
III	1,259,967	1,791.92	0.1	1,791.81
IV	194,118	17.03	0.29	16.73
Total number of pieces of mail on peak load days	1,271,383	Total number of pieces of mail for transhipment		1,077,265
Processing lead time				1,778.45 minutes
Total time required to complete the process				5 days 20 hours and 52 minutes

Source: Authors

During the peak load days (Table 4), in the standard mail sector, the implied utilization has drastically increased, and overreached capacity in the standard mail sector, which intuitively explains a long waiting time for resources in that sector (Table 4, column 8).

Table 4 Bottleneck identification of the As-Is model during the peak load days

<table>
<tr><th>Sector</th><th>Activities in the As-Is model</th><th>Number of workers per shift</th><th>Resource capacity (pieces of mail/hour)</th><th>Resource capacity per day</th><th>The average number of pieces of mail per day</th><th>Total number of pieces of mail (on peak days)</th><th>Implied utilization</th></tr>
<tr><td rowspan="2">I</td><td>Sorting parcels for transhipment and delivery (activities 10 and 11)</td><td>1</td><td>1,000</td><td>21,500</td><td>325.5</td><td>651</td><td>2%</td></tr>
<tr><td>Sorting letters for transhipment and delivery (activities 10 and 11)</td><td>3</td><td>3,000</td><td>64,500</td><td>5,382.5</td><td>10,765</td><td>8%</td></tr>
<tr><td rowspan="4">II</td><td>Sorting parcels for transhipment and delivery-import (activities 14 and 15)</td><td rowspan="2">1</td><td>4.6</td><td>98.8</td><td>9</td><td>18</td><td>9%</td></tr>
<tr><td>Sorting parcels-export (activities 14 and 15)</td><td>9.2</td><td>197.2</td><td>7.5</td><td>15</td><td>4%</td></tr>
<tr><td>Sorting letters for transhipment and delivery-import (activities 14 and 15)</td><td rowspan="2">3</td><td>20</td><td>430</td><td>99</td><td>198</td><td>23%</td></tr>
<tr><td>Sorting letters-export (activities 14 and 15)</td><td>36</td><td>774</td><td>81</td><td>162</td><td>10%</td></tr>
<tr><td rowspan="3">III</td><td>Sorting nonordinary mail for transhipment and delivery (activities 22, 27 and 31)</td><td>2</td><td>2,000</td><td>43,000</td><td>64,245.5</td><td>128,491</td><td>149%</td></tr>
<tr><td>Sorting priority mail for transhipment and delivery (activities 22, 27 and 31)</td><td>5</td><td>5,000</td><td>107,500</td><td>424,019.5</td><td>848,039</td><td>394%</td></tr>
<tr><td>Sorting recommended letters and standard dimension letters for dispatch and delivery (activities 22, 27 and 31)</td><td>3</td><td>3,000</td><td>64,500</td><td>47,113.5</td><td>94,227</td><td>73%</td></tr>
<tr><td>IV</td><td>Sorting postal items for delivery (activity 33)</td><td>5</td><td>5,000</td><td>107,500</td><td>94,522</td><td>189,044</td><td>88%</td></tr>
<tr><td colspan="2">Total number of workers per shift</td><td>23</td><td colspan="5" rowspan="2"></td></tr>
<tr><td colspan="2">Total number of workers per day (three shifts)</td><td>69</td></tr>
</table>

Source: Authors

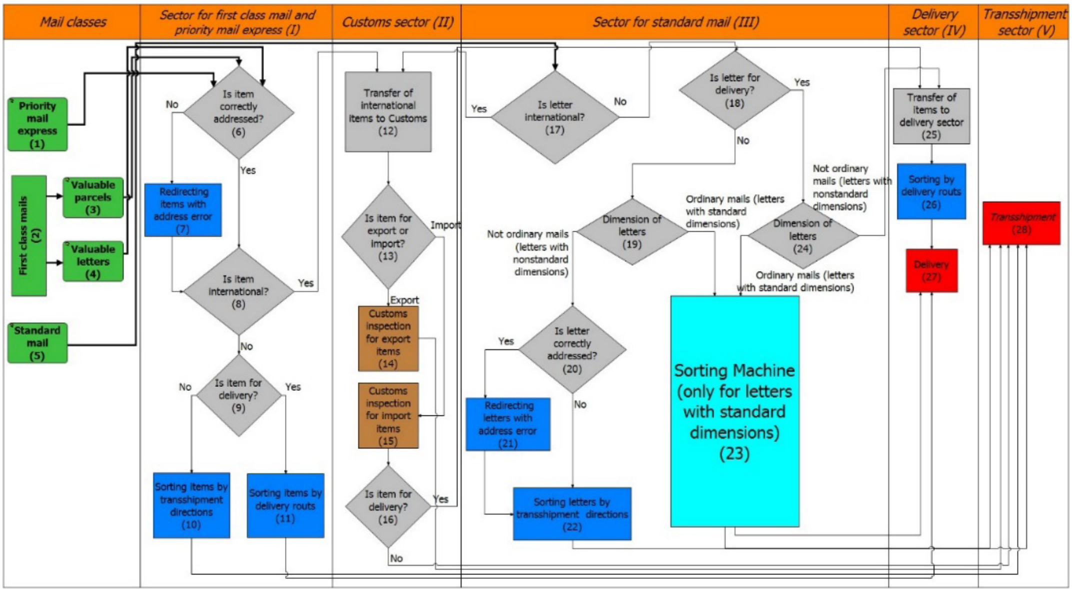
As-Is model analysis showed that the PLC has difficulties in mail processing, especially on peak load days, due to a large number of mail and small operational capacity. The analysis also showed that the PLC is a transit center due to a large number of transhipped mail. The main indicator of the operation of each transit center is the duration of the overall processing lead time, which should be as short as possible to fulfil a specified level of service.

3.3.2 To-Be model

The To-Be model is a combination of manual and automated mail processing in the PLC. Automation involves the use of computers to control machines and processes to replace human labor. Automated processing only includes mail of standard sizes (dimensions ranging between 90x140 mm and 120x235 mm). This model was developed because the Post of Serbia public enterprise planned to purchase a machine for sorting mail of standard sizes (despite the price of this machine and a decline in the volume of mail of standard sizes).

The To-Be model is structurally equivalent to the As-Is model. The differences are in a reduced number of manual workers (from 73 to 54), and in a sorting machine allocated to the standard mail sector, which sorts only mail with standardized dimensions. Figure 2 presents the process map for the To-Be model.

Figure 2 To-Be model (automated model)



Source: Authors

The To-Be model results are summarized in tables 5 and 6. In To-Be, the longest processing time is in the customs sector, which is related to the government policies and it is not possible to make changes to government policies to optimize the PLC mail processing. The second and a much more interesting change is a big reduction in processing time in the standard mail sector caused by inserting a sorting machine.

Table 5 Average processing time per mail by To-Be model sectors

Sector	Number of pieces of mail	Average processing time	Average working time	Average time spent waiting for processing
I	146,714	1.04	0.02	1.01
II	10,471	33.27	8.01	25.26
III	7,372,646	4.45	0.03	4.41
IV	2,350,375	4.83	0.11	4.71
Total number of pieces of mail in March 2023	7,519,357	Total number of pieces of mail for transhipment		5,242,636
Processing lead time				5.93 minutes

Source: Authors

Table 6 Bottleneck identification in the To-Be model during mail processing

Sectors	Activities in the To-Be model	Number of workers per shift	Resource capacity (mails/hour)	Resource capacity per one day	The average number of pieces of mail per day	Total number of pieces of mail	Implied utilization
I	Sorting parcels for transhipment and delivery (activities 10 and 11)	1	1,000	21,500	262	8,111	1%
	Sorting letters for transhipment and delivery (activities 10 and 11)	3	3,000	64,500	4,470	138,576	7%
II	Sorting parcels for transhipment and delivery-import (activities 14 and 15)	1	4.6	99	6	195	6%
	Sorting parcels-export (activities 14 and 15)		9.2	197	4	131	2%
	Sorting letters for transhipment and delivery-import (activities 14 and 15)	4	26.7	573	196	6,087	34%
	Sorting letters-export (activities 14 and 15)		48	1,032	131	4,058	13%
III	Sorting nonordinary mail for transhipment and delivery (activities 22 and 23)	3	3,000	64,500	21,312	660,665	33%
	Sorting machine activities (activities 22 and 23)	2	40,000	860,000	190,499	5,905,476	22%
IV	Sorting postal mail for delivery (activities 26)	5	5,000	107,500	27,944	866,272	26%
Total number of workers per shift		19					
Total number of workers per day (three shifts)		57					

Source: Authors

The use of machine dramatically reduces processing time in the standard mail sector and makes work easier. However, it can be concluded from Table 6 that monthly machine utilization is 22%. For this scenario, the simulation model results for peak load days are listed in tables 7 and 8.

Table 7 Average processing time by the To-Be model sectors for peak load days

Sectors	Number of pieces of mail	Average processing time	Average working time	Average time spent waiting for processing
I	11,416	1.1	0.03	1.07
II	393	33.77	7.95	25.82
III	1,259,967	5.7	0.03	5.67
IV	194,118	4.6	0.1	4.5
Total number of pieces of mail on peak load days	1,271,383	Total number of pieces of mail for transhipment		1,077,265
Processing lead time				6.38 minutes
Total time required to complete the process				Within a period (2 days)

Source: Authors

The results show that the To-Be model successfully sorts mail on peak load days and that machine capacity utilization on these days is 62%. Based on the analysis, it is determined that the To-Be model has almost five times the mail processing capacity of the actual monthly mail load.

Table 8 Bottleneck identification of the To-Be 1 model during the peak load days

Sectors	Activities in the To-Be model	Number of workers per shift	Resource capacity (mails/hour)	Resource capacity per one day	The average number of pieces of mail per day	Total number of pieces of mail	Implied utilization
I	Sorting parcels for transhipment and delivery (activities 10 and 11)	1	1,000	21,500	326	651	2%
	Sorting letters for transhipment and delivery (activities 10 and 11)	3	3,000	64,500	5,383	10,765	8%
II	Sorting parcels for transhipment and delivery-import (activities 14 and 15)	1	4.6	99	9	18	9%
	Sorting parcels-export (activities 14 and 15)		9.2	197	8	15	4%
	Sorting letters for transhipment and delivery-import (activities 14 and 15)	4	26.7	573	99	198	17%
	Sorting letters-export (activities 14 and 15)		48	1,032	81	162	8%
III	Sorting nonordinary mail for transhipment and delivery (activities 22 and 23)	3	3,000	64,500	64,246	128,491	100%
	Sorting machine activities (activities 22 and 23)	2	40,000	860,000	534,434	1,068,868	62%
IV	Sorting postal mail for delivery (activities 26)	5	5,000	107,500	31,221	62,442	29%
Total number of workers per shift		19					
Total number of workers per day (three shifts)		57					

Source: Authors

3.4 Comparative analysis of the As-Is and To-Be models

Table 9 shows a comparative analysis that helps determine which model is the best for application in the observed PLC. It can be seen in the table that the To-Be model is better, but that comes with the price since the To-Be model is significantly more expensive than As-Is, as it generates costs related to the investment in the sorting machine. These data call into question the need to automate the postal system of Serbia.

Table 9 Comparative analysis of the models

Models	Processing lead time (month) [minutes]	Processing lead time (peak load days) [minutes]	Total time required to complete the process (peak load days)	Engaged resources
As-Is	57.49	1,778.45	5 days 20 hours and 52 minutes	69 skilled workers
To-Be	5.93	6.38	On time (within 2 days)	57 skilled workers + sorting machine

Source: Authors

4. Conclusion

In business logistics micro- and meta-systems, processes can be represented as a series of related logistics activities executed using the working system resources to create value for the customers. The efficiency of the executed processes directly affects the overall efficiency of the entire logistics subject. This paper deals with this kind of problem.

In this paper, through a case study in the postal center as a distribution hub that exists within the postal logistics network of the Republic of Serbia, different variants of the unfolding of logistics processes were investigated. In order to raise productivity and overcome operational difficulties, two process models were developed, and the results showed that through organizational and structural changes of the existing processes via the To-Be model, operational problems can be eliminated sufficiently well. Besides, research results show that the use of DES in the PLC is fully justified and recommended. Research limitations are related to the implementation of reengineering changes in the To-Be model, which was beyond the scope of this paper.

Findings from this paper have two practical implementations. The first implementation is to use As-Is models as an insight into the current situation in the PLC. The second implementation is to use a To-Be model as a decision support system for evaluating different solutions in the execution of logistics processes and also for argumentation in the planning of investments in machinery and equipment.

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